

*Edna Adelson · Paul Bach-y-Rita · Gershon Berkson  
Joan Chase · Stella Chess · Paulina Fernandez  
William Fowler · Selma Fraiberg · Bernard Z.  
Friedlander · Agnes H. Ling · James W. Prescott  
Charles E. Rice · Manly Spigelman*

**on**

*the effects  
of blindness  
and other  
impairments  
on early  
development*

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*Zofja S. Jastrzemska* Editor



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New York 1976

RESOURCE ROOM  
FOR VISUALLY HANDICAPPED  
MARIN COUNTY

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## INTRODUCTION

This volume is based on a conference held in Ann Arbor in 1972. It is, of course, impossible to reproduce in a book the atmosphere of a successful meeting. However, the discussions and informal presentations have been incorporated into the book for two main reasons. In the first place, many questions were raised and ideas discussed which may be either of practical use for persons working with impaired children, or of heuristic value for researchers in this field. Many of these would have been lost if only the formal papers were included. Secondly, the less formal material may be more approachable reading for those practitioners who have a distaste for the rigid format of scientific papers. For such readers the "live" portions of the book could perhaps serve as an introduction and enticement to peruse the formal papers.

There are several points implied in, or emerging from, the contents of this volume which should be underscored. One of these is that an understanding of the underlying processes is of crucial importance for effective intervention. The comparisons made by Adelson and Fraiberg between their own group of blind children and that of Norris and her co-workers illustrate this. It must be emphasized that the care and stimulation given the group of blind children in the Norris study was revolutionary in its excellence and effectiveness. It was, however, a pioneering effort which had relatively little prior detailed knowledge to draw upon. Global observation and description had been done, but not the systematic tracing of the genesis of very specific developmental achievements, such as independent locomotion, orientation to sound, or the concept of self. A detailed understanding of the processes involved can provide the basis on which specific interventions to remedy a delay or problem in development can be planned. This kind of knowledge is still very scarce, despite a great deal

of activity labeled (or mislabeled) research. Intervention programs must proceed despite this, and often do so with considerable success. However, the maximum effectiveness attainable at any given time depends on the full use of the knowledge available at that point.

Regarding intervention, during one of the discussions Dr. Stella Chess raised a very important question: what is the utility of efforts to produce attainment of developmental milestones "on schedule" by children who, by the very nature of their impairment, are bound to follow a different course than the non-impaired. Here also, an understanding of the processes involved could provide the answer. It would enable us to distinguish the instances of unsurmounted obstacles to development from those in which circuitous but effective alternate routes were being taken.

Another advantage of the scientifically rigorous approach is exemplified in the Chess and Fernandez paper. It has long been a cliché among workers with handicapped children that the degree of impairment bears no direct relationship to how well the child is able to function. There are multiple reasons for this, parental attitudes being an obvious one. The temperamental characteristics identified by Dr. Chess and her co-workers are another major factor in the ability to overcome the handicapping effects of impairment. An evaluation of the child along these dimensions, however, provides something far more valuable than mere prediction of ease or difficulty of habilitation. It also provides quite specific indications as to the kind of approach most likely to succeed with a particular child, through an objective description of his behavioral style. It would be eminently desirable to take as much account of a child's temperament as of his intelligence in planning an

educational or other program for his benefit.

Finally, I would like to close by making a plea for attention to two topics which I feel may warrant further examination. The first is the whole question of movement stereotypes, sometimes called "blindisms" when they occur in blind persons. It has been surrounded with much emotion but little systematic study. I would like to suggest two things: that a better understanding of the phenomenon may enable us to use it as an indicator of certain aspects of a child's functioning, and perhaps point to unmet needs. And, secondly, that a more articulated and detailed look is needed for such understanding. We may be lumping diverse behaviors under that label. There are some pointers, for instance, that eye poking is more directly related to visual impairment, while true movement stereotypes such as rocking are related to somatosensory deprivation. Much in Dr. Prescott's paper is of great interest in relation to this problem. The other topic was beautifully illustrated in the film presented by Edna Adelson. In the final sequence the first and absolutely radiant smile exhibited by the

previously stolid little boy, occurred when he finally managed to retrieve a desired object through his own efforts. This aspect of functioning was also later referred to by Dr. Friedlander as the "self as doer." This area has many aspects. It is the observation and experience of cause and effect. The experience of oneself as capable of producing effects on both one's inanimate and human environment. And the experience of attaining desired ends through one's own efforts. I believe that this--and I think of it globally as "participation in causality"--is a very basic need for living organisms. The blind child is severely limited in this area both by the inability to observe causal sequences of events visually, and by the helplessness and dependence on others which is even greater than that of the sighted infant. Much attention has been given to providing perceptual information and thus enhancing cognitive development. I would like to suggest that we also need to emphasize an enrichment in the experience of "making things happen" for the sake of its effect on both cognitive and emotional development.

---Zofja S. Jastrzemska

## First Session

### SENSORY DEFICIT AND MOTOR DEVELOPMENT IN INFANTS BLIND FROM BIRTH

Formal Presentation: Edna Adelson and Selma Fraiberg\*

It is well known that among children in the general population designated as blind there are marked delays in locomotor achievements by sighted standards. In one metropolitan sample studied by Norris, Spaulding and Brodie (1957), in a group of 66 children blind from birth and neurologically intact, only 50 percent were walking independently at 24 months.

#### GROSS MOTOR DEVELOPMENT STUDY

At the Child Development Project we have completed a longitudinal study of the course of gross motor development in ten infants blind from birth. The investigation was in the context of early ego development and included such areas as human attachment, object concept development, language, and prehension.

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Senior staff who participated during the children's first two years in research and intervention programs were: Morton Chethik, Winifred Connelly, David A. Freedman, Ralph Gibson, Barry

Preliminary findings on a smaller number of infants were reported in earlier publications (Fraiberg and Freedman, 1964; Fraiberg, Siegel and Gibson, 1966; Fraiberg, 1968). In those papers we described the patterns which emerged consistently for each of the children:

1. Postural items testifying to neuromuscular maturation in control of head and trunk appeared within the range for sighted children;
2. The mobility items which normally follow each postural achievement were considerably delayed;
3. The onset of self-initiated mobility was related to the demonstration of each child's ability to reach out and attain an object presented by sound cue alone.

Our prehension study provided the first clues to the delayed mobility of blind children. The blind child does not reach for and attain a sound object until the last quarter of the first year, and proficiency in *reach on sound* may not be attained until the next quarter. When sound provides the lure for reach, the blind child begins his mobility.

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Siegel, Marguerite A. Smith, Lyle Warner and the authors.

Our appreciation goes to Steven Doehrman for statistical consultation. A different version of this paper, titled "Gross Motor Development in Infants Blind from Birth," appears in *Child Development*, March 1974.

In this paper we will bring together our central findings on the characteristics of gross motor development in our blind research sample. We will compare the achievements of children in our group with those of sighted children using items from standard motor scales, and we will compare our group with a larger blind sample reported in the Norris study of 1957. In a concluding section we will examine in some detail the impediments to locomotion which appeared in longitudinal profile and the implications of these findings for the study of the role of vision in motor development of intact sighted infants.

## METHOD

### Subjects

The ten blind infants in the research group (Table 1) joined the Child Development Project when they

were between one and eleven months old. Any infant who matched the criteria when referred was accepted. All the children in this group have been followed past their second birthdays.

This is a unique sample and does not represent the general blind child population. Intact totally blind infants are rare. We located only two each year even though we had the extensive referral resources of two large medical centers in Ann Arbor and of a pediatric ophthalmologist in Detroit. Within this group there was considerable variation in the causes of blindness and in the educational and social status of the parents. However, all the infants were totally blind or had no more than minimal light perception. There were no other discernible handicaps or neurological damage.

TABLE 1

### Child Development Project Blind Infant Group

#### CRITERIA

Total blindness from birth or only minimal light perception.  
No other known handicaps or neurological damage.  
Less than one year old.  
Within fifty miles of our office.

#### DESCRIPTION

Sex. . . 5 boys, 5 girls.  
Age at referral. . . 1 to 11 months (1 to 8 months with correction for prematurity in 3 cases).  
Age last seen. . . 2 to 6 years.  
Ordinal position in family:  
    only (5)  
    first of 2 (1), of 3 (1)  
    second of 2 (1)  
    fifth of 5 (1)  
    sixth of 6 (1)  
Diagnosis. . . hypoplasia of optic nerve (3)  
                retrolental fibroplasia (3)  
                (3 months premature birth)  
                infantile glaucoma (2)  
                ophthalmia neonatorum (1)  
                resorption of vitreous humor (1)  
Light perception . . . 2 boys, 2 girls  
Social class by father's occupation: \*  
    managerial (1)  
    college student (2)  
    skilled (2)  
    semi-skilled (3)  
    unskilled (2)

\*Edwards' Occupational Index

## Intervention

All of the children in our sample have received educational guidance from our project from the point of entry into the program. The first babies provided many of the essential clues to the impediments of blindness in the areas of mother-child interaction, adaptive hand behavior, gross motor development, and the construction of an object world. As our knowledge progressed we were able to translate our research findings into a developmental guidance program.

In the area of gross motor development we were able to infer from the lag between *postural readiness* and the *mobility* item that should normally follow each postural achievement, that an external stimulus normally provided by vision creates the incentive for reaching and extension of the trunk which initiates the locomotor sequence. From our blind prehension study we learned that sound does not provide a stimulus for intentional reach and attainment of an object until late in the first year. The first demonstrations of *reach on sound* in our sample appear in the last quarter of the first year and do not become proficient for another three to six months. No child in our sample demonstrated a form of prone progression or upright progression before he had first demonstrated in our prehension study *reach on sound cue alone*, the coordination of ear and hand which enabled pursuit by hand and extension of the trunk toward an external lure.

In the developmental guidance program we encouraged and promoted all those experiences in which sound and touch could bring meaning and reward. And, because the baby's human partners give meaning to all sense experience, our program was centered in the parent-child relationship. Physical closeness united with the sound of the parent's voice provided the first union of tactile-auditory experience for the children. At the same time we provided toys and a wide range of experiences for the hands in which explorations brought reward and ultimately a sound-touch identity for people and things (Fraiberg, Smith, and Adelson, 1969; Fraiberg, 1971).

We reasoned that everything we did to promote sound-touch experience

for the hands would facilitate the coordination of ear and hand in directional reach and attainment of an object. We reasoned further that everything we did to facilitate *reach on sound* would have an effect in initiating locomotor sequences. Wherever vision would normally facilitate experimentations in a new posture we built in sound-touch experiences which would make the new posture *interesting* for a blind child, and would lure him into postural shifts and mobility. We also suggested to parents that they play infant games with the baby to encourage him to use his body in many different positions, so that all postures became comfortable and familiar to him. Our interventions, then, provided in a sense, the experimental conditions for examining certain hypotheses which appeared early in our work.

Our findings, as presented in this paper, probably reflect the positive effects of intervention.

## Observations and Scoring

We visited the babies' homes twice a month and the babies were observed in such ordinary daily activities as feeding, bathing, and playing. Narrative notes of direct observations of each child were recorded during the visit. In addition, film samples of gross motor and other behaviors were taken monthly.

In analyzing the gross motor material we used the filmed demonstration of achievements wherever possible. A second choice was the observer's detailed description in the notes. There were very few instances when we relied upon a parent's report.

We rounded the ages to the nearest half month before obtaining the age range and median age for an item. Three babies in the group were three months premature. We corrected those ages for all comparisons with sighted children. However, for comparison with the other blind research group, uncorrected ages were used to correspond to Norris' procedure.

## Comparison Groups

Initially, in order to compare the gross motor achievement of our ten blind infants with the normal sighted population we chose the gross motor items and criteria described by Gesell and Amatruda (1947). These cover a broad scope, giving the major mobility milestones of creeping and walking as well as a wide variety of precursor postural achievements. Norms for the age of each achievement are also provided. In 1969 the Bayley Scales of Infant Development were published, (Table 2). These were based on a more representative sample of the sighted population and provided the researcher with a normal age range as well as median age of achievement. This gain, however, is somewhat offset for our purposes by the loss of several items that are of particular interest to us. The material shown in Table 3 and Figs. 1 and 2 for comparison of our blind group with the sighted population does not represent all the items of the gross motor sequence that we wish to examine. For one item "walks well across room" which is not in the Bayley Scales, we have, with reservations, included the item from the Denver Developmental Screening Test for roughly comparable sighted age range and median age. Consideration of "bridging on hands and knees," and "creeping" will be postponed until the discussion section.

We also wanted to be able to compare our finding on ten blind infants with a similar blind population. For this we have used the larger group of 66 blind infants in the study reported by Norris et al. Norris used locomotor items from the Maxfield-Fjeld Tentative Adaptation (for visually handicapped preschool children) of the Vineland Social Maturity Scale. Several items on this scale can be credited by parent report. As with the Bayley Scales, not all gross motor items that we consider pertinent to the blind child's motor development are included.

Certain differences between the Child Development Project blind infants and the blind infants in the Norris study should be kept in mind. Both groups excluded children with additional handicaps. The children in the Norris group probably had some advantage over the total or near total

blindness of the children in the Child Development Project group since the Norris criteria included varying degrees of "educational blindness." Any child in that group could be "expected to require the use of braille for his education," but need not be totally blind. The Norris children, however, may have been disadvantaged by the greater number of premature births (87 percent compared to 30 percent) and multiple premature births (21 percent compared to none). In addition, some Norris subjects did not enter the study until 4 months later than the oldest subject in our group (up to 15 months old compared to 11 months). They were also seen less frequently (usually at three-month intervals compared to two-week intervals).

## RESULTS

### The Blind and the Sighted-- A Comparison

Table 3 and Figs. 1 and 2 match the findings for the Child Development Project blind group to Bayley's age ranges and median ages for the normal sighted population. The sequence of motor items is essentially similar for both the blind and the sighted children. Age, sex, light perception, and prematurity are not systematically related to gross motor development within this group of ten blind children. In Fig. 1 it can be seen that there are five items where almost all the blind infants are on schedule when compared to sighted children. The other five items are delayed considerably beyond the sighted age range for 40 percent to 90 percent of the blind group. The age ranges and median ages for all the items are given numerically in Table 3.

The items that fall within the sighted age range are: "sits alone momentarily," "takes stepping movements when hands are held," and "stands alone." The sitting, standing and stepping items would seem to indicate a normal sequence and rate of maturation for control of the trunk, the ability to bear weight on the legs, and the ability to make alternating leg movements with support. Adequate head control was also demonstrated by each of the children in the group. However, it does not

TABLE 2

## Selected Items from the Bayley Scales of Infant Development

Elevates self by arms, prone. Place the child on his stomach on a firm surface. Observe whether he elevates himself by his arms, lifting his head and shoulders from the table surface by his arms, hands, or elbows. Credit if the child elevates his head and upper trunk in a voluntary push-up.

Rolls from back to stomach. Allow the child to lie on his back free from restrictions on a flat surface. As an incentive, a toy may be placed to one side and out of reach of the child. Credit if, under this or any similar situation during the examination period, the child rolls from his back onto his stomach.

Sits alone momentarily. Place the child in a sitting position on the table, with his legs straightened and spread at an angle of about 50 degrees. Credit if the child sits momentarily without support.

Sits alone, steadily. Same situation as "sits alone momentarily." Credit if the child sits alone steadily without support and with his back fairly straight.

Prewalking progression. Place the child on his stomach on a firm flat surface, with a toy in front of him but out of reach. Note the child's mode of locomotion. Credit if the child makes forward progress of 9 inches or more on his abdomen (crawling), on his hands and knees (creeping), on his hands and feet (quadruped), or in a sitting position (hitching on buttocks).

Raises self to sitting position. Observe the child while he is lying in the crib or playpen during free play. A toy placed out of reach on the crib or pen rail may be used as an incentive. Credit if the child pulls himself to a sitting position, using the sides of the crib or pen for support.

Stands up using furniture. Observe the child while he is in the playpen or on the floor. Note whether the unaided child pulls himself to a standing position by using a chair, rail, or other convenient object. A toy placed out of reach on the chair or pen rail may be used as an incentive. Credit if the child raises himself to a standing position, using a chair or other convenient object for support.

Stepping moments. Stand the child on the floor, holding his hands to support him. Credit if the child attempts to walk by making coordinated alternating stepping movements but still relies on your support.

Stands alone. Place the child in a standing position out of reach of any supporting object. When he is stably balanced on his feet, remove the support of your hands. Credit if the child maintains a standing position for a few seconds.

Walks alone. Same situation as "stands alone." Credit if the child takes at least three steps without support.

TABLE 3

Child Development Project Blind Compared  
with Normal Sighted Population

(N = 10)

| Item                                                          | Age Range     |             | Median Age |       |
|---------------------------------------------------------------|---------------|-------------|------------|-------|
|                                                               | Sighted       | Blind*      | Sighted    | Blind |
| Elevates self by arms, prone <sup>a</sup>                     | 0.7 - 5.0     | 4.5 - 9.5   | 2.1        | 8.75  |
| Sits alone momentarily                                        | 4.0 - 8.0     | 5.0 - 8.5   | 5.3        | 6.75  |
| Rolls from back to stomach <sup>a</sup>                       | 4.0 - 10.0    | 4.5 - 9.5   | 6.4        | 7.25  |
| Sits alone steadily                                           | 5.0 - 9.0     | 6.5 - 9.5   | 6.6        | 8.00  |
| Raises self to sitting position <sup>a</sup>                  | 6.0 - 11.0    | 9.5 - 15.5  | 8.3        | 11.00 |
| Stands up using furniture <sup>a</sup><br>(Pulls up to stand) | 6.0 - 12.0    | 9.5 - 15.0  | 8.6        | 13.00 |
| Stepping movements <sup>a,b</sup><br>(Walks hands held)       | 6.0 - 12.0    | 8.0 - 11.5  | 8.8        | 10.75 |
| Stands alone <sup>a</sup>                                     | 9.0 - 16.0    | 9.0 - 15.5  | 11.0       | 13.00 |
| Walks alone, 3 steps <sup>a</sup>                             | 9.0 - 17.0    | 11.5 - 19.0 | 11.7       | 15.25 |
| [Walks alone across room] <sup>a</sup>                        | [11.3 - 14.3] | 12.0 - 20.5 | [12.1]     | 19.25 |

\*Ages rounded to nearest half month, 3 cases corrected for 3 months prematurity.

<sup>a</sup>1 child had not achieved by 2 years.

<sup>b</sup>1 child not observed prior to walk alone.

[ ]Item from Denver Developmental Screening Test.

Bayley range = 5-95%

Child Development Project range = 10-90%

Denver range = 25-90%

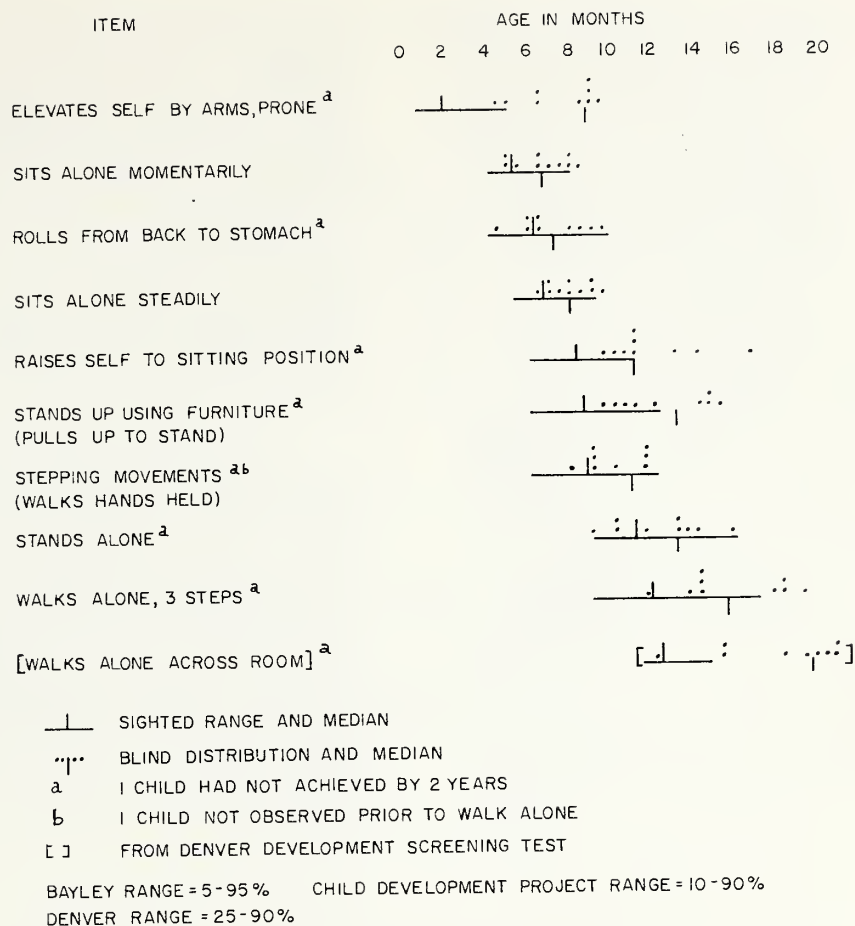


Figure 1. Distribution and median age of Child Development Project blind group compared to sighted age range and median age (ages of blind group rounded to nearest half month, 3 cases corrected for 3 months prematurity).

appear as a separate item in the table or figures since we have direct observations for only three of the children who were seen before four months. The other children were first seen at four to eleven months. According to the parent's reports they held their heads erect and steady within the sighted range. "Rolls from back to stomach" is the only mobility item to fall within the sighted range and remains an enigma at present.

The items that show a serious delay are: "elevates self by arms, prone," "raises self to sitting position," "stands up using furniture (pulls to stand)," "walks alone, three steps," and "walks alone across room." With the exception of the first item these all involve what we will call self-initiated mobility. In Fig. 2 where the blind and sighted median ages are plotted beside each

other and the curves drawn, we can see the repeated pattern of on-schedule postural achievements followed by diverging curves when self-initiated mobility or a shift of posture in response to external stimulation is called for.

We would argue from this that vision must play a more central role in the achievement of mobility and locomotion than it does in the establishment of stable posture. For the blind child there will have to be some adaptive substitution of sound for sight to prompt the beginning of self-initiated mobility. This substitution occurs toward the end of the first year.

#### Comparison of Two Blind Groups

Since the number in our group was small we wanted to compare our findings

with a larger similar group where data had been collected on comparable gross motor items. Norris, et al. followed 66 subjects, the largest group reported in literature. The Norris data is reported as <25 percent, >25 percent >50 percent, or >75 percent of the sample having achieved an item during a particular three-month interval. Not all these percentages are given for each item. On seven items for which we have comparable data there is a >50 percent Norris entry indicating that 50-74 percent of her group achieved it at that age. This is not a median age figure. We have compared it with the 60th percentile of our blind group in Fig. 3. There are nine comparable items with a >75 percent Norris entry indicating 75 percent or over of her group achieved it at that age. This is not the 75th percentile. We have compared it with the 80th percentile of our group in Fig. 4.

In both figures the items have been rearranged to correspond to the actual order of achievement of the

blind children which is somewhat different from the order for sighted children. The similar shapes of the curves of the two groups would indicate that our group of ten did resemble the larger group of blind children studied by Norris. A regular pattern of gross motor development is shown in both groups and while it may differ from that for the sighted population, it probably represents normal development for the child who is blind from birth, and has no other handicap.

It should also be noted that in both Figs. 3 and 4 there is an age differential between the two groups that grows greater with time. This is most striking in Fig. 4 where the children from the Norris group are from seven to thirteen months later than the Child Development Project group on the last three items of the sequence: "stands alone," "walks a few steps," and "walks across room." Differences in sample characteristics have been discussed earlier and may account for some of

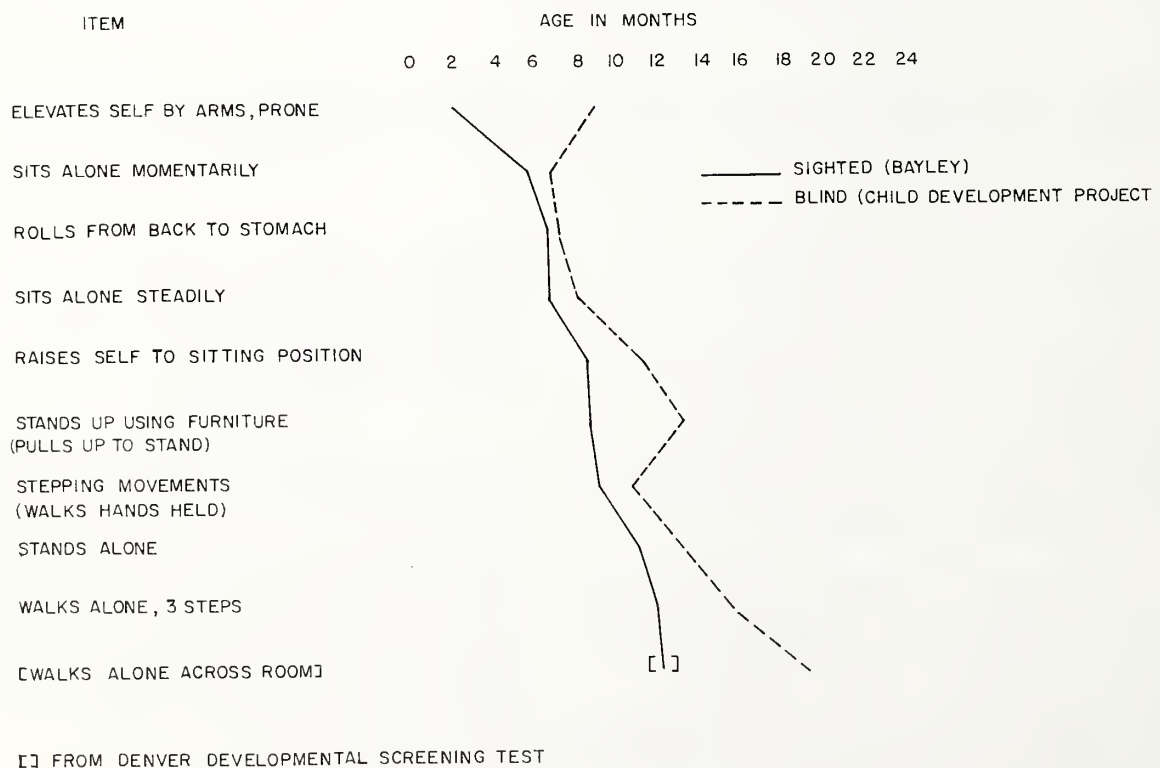
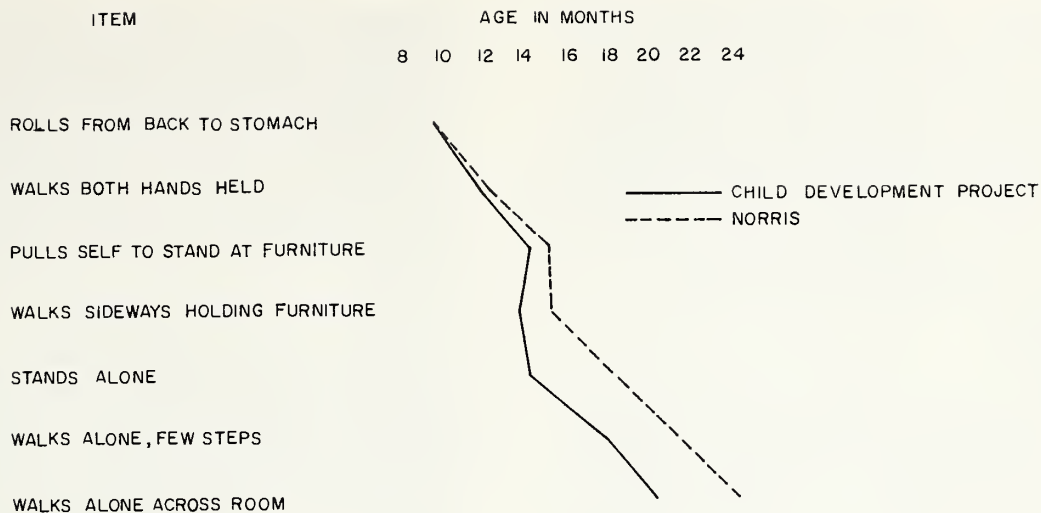


Figure 2. Blind and Sighted Median Ages. (Ages of Blind Group Rounded to Nearest Half Month, Three Cases Corrected for Three Months Prematurity.)



Note: Appreciation is acknowledged to Dr. Steven Doehrman for statistical consultation.

Figure 3. Two blind groups compared: Norris >50 percent, with Child Development Project 60th percentile. (No age correction for prematurity.)

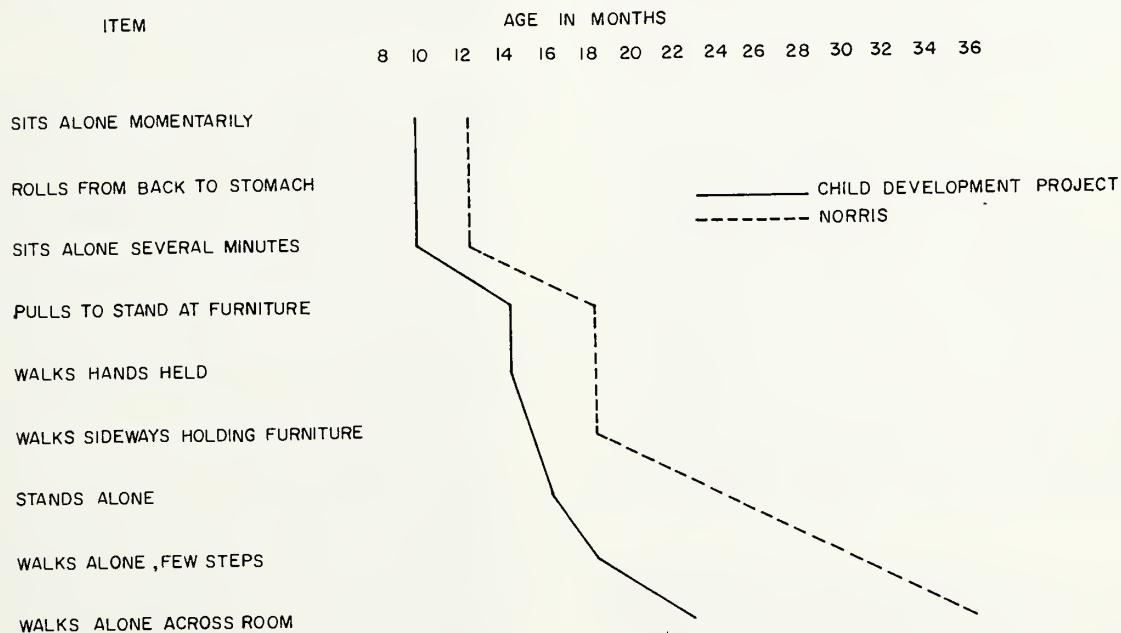


Figure 4. Two blind groups compared: Norris >75 percent, with Child Development Project 80th percentile. (No age correction for prematurity.)

this delay. It is probable that the earlier achievements of the children in our blind group represent the cumulative effects of the intervention program. Delays in mobility and locomotion were decreased when we were successful in providing auditory-tactile hand experience that would ultimately permit sound to serve as a lure for forward progression.

## DISCUSSION

There is a start-and-stop character to the normal pattern of gross motor development in blind children that is confusing and distressing to the anxious parent. In early infancy the blind baby supports his head well when he is held upright or in a supported sit. Placed on his stomach, however, at any age up to five months he is unlikely to bring his arms forward, to raise his head high, and clear his chest from the surface. There is nothing in his other behavior to indicate a lack of strength or coordination of his arms or neck or back. But suddenly he seems inadequate. A few months later the blind babies are sitting briefly and then well, and doing so within the normal range for sighted infants. But they do not advance to the next set of accomplishments which would involve moving themselves from supine to sit or from sit to stand at anything like the rate of progress for the sighted child. Creeping is markedly delayed. Development seems to have come to a halt. Toward the end of the first year blind children take steps with hands held and can stand alone within the sighted range although the medians are about two months later. Once again, however, there is a disquieting pause before the next steps (quite literally) are taken. The sighted child can walk independently about three months after he walks with his hands held. The blind child may not do so for eight or nine months.

We are not concerned with the simple performance of any motor item for its own sake. There are children with severe motor handicaps who develop adequately in most other areas. For the young blind child, however, anything that further restricts his already limited access to external stimulation is of great moment because it may prevent his acquisition of objective information about events and

objects around him, and it may encourage a dangerous passivity and subjectivity thus threatening all of early ego development. Gesell and Amatruda (1967); Norris, Spaulding, and Brodie (1957); and Parmelee, Fiske, and Wright (1959) have found that blindness from birth need not by itself cause serious developmental delays. Yet we know that a large number of congenitally-blind children do meet with grave difficulties that result finally in deviant personalities with pessimistic prognoses (Fraiberg and Freedman, 1964). The blind child's special pattern of gross motor development claims our attention because the periods of delay that are "normal" for the blind child probably represent periods of serious developmental hazard.

Undoubtedly equilibrium and fluent motor coordinations are affected by lack of visual feedback, and there certainly are fewer possibilities for imitation. Nevertheless, control of the head and trunk in sitting and standing positions and the alternating leg movements with hands held are entirely within the sighted range. When there is still a delay in mobility, even with well-mothered, well-stimulated blind infants, it is probably related to a lack of external incentive.

In infant testing we use visual lures to entice the sighted child to pull himself up to a stand, or to move forward in prone. We know he is likely to reach for whatever he sees from four and one-half months on. Less often noted is the fact that the sighted infant does not reach for what he only hears but cannot see until late in the first year (Piaget, 1936; Freedman et al. 1970; Fraiberg, Siegel, and Gibson, 1966). This has special significance when we wish to lure the blind infant into motion, to get him to pull up to a stand, or to move ahead to grasp a toy out of his immediate reach. Until he has demonstrated a response of movement to seek an object at a distance by sound alone, we cannot lure him from one place to another; he remains immobile in spite of demonstrated motor competence. This point has been examined in detail in our 1966 paper. It has been borne out in the cases we have seen since then.

Perhaps the best way to appreciate the blind child's dilemma would be to look closely at gross motor development from the very beginning of the first year. We will do this by dividing the first year into four-month intervals, comparing normal sighted development with normal development for the blind child for each period.

#### Birth to Four Months

The early developmental pace is a rapid one. If we observe a sighted infant when he is picked up and held against the shoulder of his mother, we note his increasing ability to adjust to her posture and to control the position of his head. From as early as 1.3 months median age, he turns his head spontaneously from side to side and "inspects" the surroundings (Bayley). When wide awake and active he seems to seek stimulation with his eyes and by the turning of his head multiplies the visual possibilities. At about one and one half months he turns his eyes toward a light source. If at two months we place this baby on his stomach, he responds by bracing himself with his arms to lift his head high, to raise his chest off the flat surface. This puts him in the best possible position to continue to look around which he will do until his arms and back tire. This mobility of the head in the service of the eyes continues. At three months the sighted baby tracks a rolling ball or follows a moving hoop or a falling object. At nearly four months he turns his head to the sound of a rattle or bell.

Now let us turn to an alert wide awake blind infant. He, too, will mold comfortably to his mother's chest and shoulder. He, too, will soon be able to carry his head high and steady. We would have guessed that erect head posture depended upon fixation of the eyes upon some reference point in the visual field. Yet this seemed not to be so in the blind infants we followed. But there were two important differences even at this early age between the blind and sighted infants. First, whether the blind baby was held upright against his mother's shoulder, or settled comfortably upon her lap, he did not move his head from side to side; he tended to keep it centered. He could turn his

head (two of the three children we saw before four months did turn to the sound of a test bell), but seldom did so. Sound did not seem to have the same exciting and attracting qualities for the blind infant of this age that sight provided for the sighted infant.

Second, the parents reported that their blind infants did not like the prone position. Each mother placed her baby on his stomach on the floor to show us what she meant. We saw all too clearly. The babies struggled to clear their heads and noses from the surface by arching the back or stretching the neck. They protested and looked uncomfortable and unhappy or else gave up and simply rested with cheek upon the floor. There was no sustained lifting of the head and no bracing with the arms to aid them in maintaining a more comfortable, more adaptive posture. The sound of favorite toys or mother's voice, the touch of gentle patting on head or back made no difference. Just as the blind baby did not scan the world about him by moving his head when he was held by his mother, so in the prone position he did not raise his head to take in more of the external world around him. For him there was no adaptive advantage in head mobility, no enticement, no reward that could equal what was usually offered by visual stimulation.

Elevating the head and chest by use of the arms when prone was one of the items that was delayed by more than six months in comparison to the sighted median age. For almost all the blind infants in our group it did not occur until after they were able to roll over from back to stomach which they did within the sighted age range, four to ten months. This, then, represents a different order of achievement from that of the sighted infant but it seems to be normal for the infant who is born blind.

#### Four to Eight Months

This is a period when the sighted child gains full mastery over the sitting position. By six and one-half months he can sit independently and steadily. Placed on the floor in supine position at the same age he can roll over and get onto his stomach. At an earlier stage he reached out

into the visual environment with his eyes and his head followed, moving from side to side or up and down. Now he reaches out with his arms. His eyes and hands have been coordinated since four and one-half months. On his stomach he looks about, reaches out with his hand, and in so doing pivots out of his original position. By seven months he will, by one means or another, move ahead to get an attractive toy that is held in front of him out of his reach. One way or another the sighted child can begin to get from here, where he is, to there, where the toy is. He sees it, he wants to hold it, he moves toward it by crawling or creeping or hitching in sit.

What of the blind child? He has no trouble maintaining a good sitting posture, at first briefly, and then for a longer period. He may not find it interesting if he does not have something to play with but he can sit independently well within the sighted age range. He can also roll from his back to his stomach within the sighted age range. Of course this puts him in a position he has never favored and so he is likely to roll over once again into supine. The blind baby can sit and can get onto his stomach. *What he cannot do or rather, what no child we observed would do before ten and one-half months, is attempt to make any forward progress to get closer to a toy which he likes when it is held in front of him but out of his reach.* If a toy he is playing with is removed from his grasp so that he cannot touch it, the blind infant can search with both arms across the table top or through the space that lies within arm's reach in front of and to the side of him. If the toy is not there, he is at a total loss to know what to do. He has no clues about its location or even its continued existence. One way to offer him additional cues is to use a sounding toy, such as a bell, or a favorite musical stuffed animal. For some of the children this made no difference whatsoever during this period. There was protest over removal of the toy, quiet listening, and then blank-faced passive waiting without reaching, even though we sounded the toy very close by. Other children, however, reacted with their hands even though they did not make attempts at a directed

reach or locomotion. It was through those hand responses, that we were able to watch the blind child gradually unite tactile and auditory experience. The eventual coordination of ear and hand in reaching out for the distant object (which occurs much later than the eye-hand coordination of the sighted child) would finally motivate him to creep\* toward an interesting object that he heard and wanted to grasp. But the median age of 13.25 months for that mobility item was six months later than the sighted child's crawl or creep or hitch (Bayley: 7.1 months).

It should be added that this delay cannot be accounted for by any equivalent delay in fine motor coordination. The blind children were using their hands well. They demonstrated mutual fingering and transferring of an object from hand to hand, bringing toys to the mouth and banging toys on the table in an age range that overlaps the sighted age range. And they were, in most cases, given good experience in hand play with toys that combined interesting tactile and auditory qualities.

#### Eight to Twelve Months

In this last period of the first year, the sighted child is quick to take advantage of the possibilities for combining his old skills with his new maturation. Once he discovers how to get up into a sitting position, he sets his sights higher and soon can pull himself up to a stand. With the support of a helpful adult or a piece of furniture he begins to take steps. He experiments with letting go and standing alone, and near his first birthday can take several steps as he hurls himself toward his waiting mother's arms. It will not be long before he gains sufficient control of an unsupported stand and alternating leg movements to be able to make his way across an entire room.

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\*We are using Gesell's definition of forward progress on hands and knees. At this stage of data analysis we have not found examples of other forms of prone progression corresponding to the Bayley item "prewalking progression."

There is an urge to motor activity at this age that is unmistakable. There is a pleasure in new motor mastery. But we may overlook, in observing the sighted child, the contribution of vision to his eager self-confident adventuring. Each change in position from sit to stand, or from stand to sit, each step he takes whether supported or not, produces an endlessly varied and fascinating series of visual spectacles. Wherever he casts his eyes the space is furnished with a mixture of shadows and textures and patterns and contrasts and three dimensional objects including the people he knows. One glance brings him the entire scene and informs him about his relationship to each element.

While the sighted infant is advancing from crawling to creeping and to independent walking, the blind child has yet to make his first attempt at independent mobility. He sits independently within the sighted age range and he will stand alone within the sighted age range. He will also support himself upon hands and knees at pretty close to the sighted age range. But he does not move into or out of or forward from these postures on the same timetable as the sighted child.

With each postural advance both the blind and sighted children relinquish a major portion of their actual contact with the supporting surface of the floor. In supine or in prone the infant can be in touch with the floor from head to foot. When he sits up only half his body, buttocks and legs, rests on the floor. When he finally stands and lets go of the supporting rail he feels the floor with only the bottom of his very small feet. The blind child makes all these changes but stays put for a long time after each new posture is achieved.

It is not for a lack of motor impetus. Many of the children rocked vigorously and perhaps impatiently in sit, on hands and knees, and in stand. Peter Wolff (1968) has described these patterns at transition points in sighted children as well. As mobility is mastered in relation to each posture, the rhythmic activity diminishes and disappears. In the blind infant it may be more prolonged because at each point along the gross motor sequence the self-initiated mobility

that should follow upon the new posture is delayed.

The median age for getting up into a sit and for pulling up to a stand on furniture lie at or beyond the upper limits of the sighted age range, and while Gesell describes the forty-week old infant as bridging on hands and knees and almost immediately creeping thereafter, the median ages of bridging and creeping in our group were four months apart. We understand each instance of marked delay in motor progress to indicate the effects of the missing sense, vision. When the normally fluid transition from "independent sit" to "shifts into and out of sit" does not occur, we infer that motivational factors provided by vision are present in the sequence for sighted children which are absent for the blind children. We can trace the development of a motivational force in our observations of hand behavior in the blind child. When the blind infant does not persist in his efforts to retrieve a toy we have taken from him, when he does not reach out to take hold of an attractive toy that we sound within arm's reach, we speculate that for him there are as yet no furnishings and objects surrounding him except those that exist when he is in immediate contact with them. He acts as if the fallen toy had totally disappeared, as if the sounds of familiar objects were disembodied and had no connection with the same objects that he himself held and had made to produce sounds. If we can fairly describe the sighted infant's larger environment as "fully furnished and tempting," for the blind infant, the appropriate adjectives might be "featureless, unattractive, possibly frightening."

Earlier we reported on several of the first cases in the study who did not creep until they had first reached out into space with their hands for something they heard and wished to hold. Once this reach on sound was achieved mobility soon followed. And as each child began to raise himself into a sit and up to a stand and to creep across the floor, he could map the space around him as he went and begin to furnish the void, slowly. When he stood up he would come upon things from a new angle and would need to re-map his entire space once again. He could

not do this with one sweeping glance as the sighted child can. He would have to do it painstakingly, one step at a time so to speak, feeling his way repeatedly as he gained familiarity with his old world in a new position.

If we were to stop our observations at the end of the first year, less than half of the blind infants would have begun to creep and only one child would have taken first steps and begun to walk well. The others would take considerably longer. The median age for creeping was 13.25 months; probably six months late by sighted standards (Gesell). The median age for independent walking across the room was 19.25 months; a seven-month delay.

In gross motor development lack of vision presents the blind child with a double handicap: he has only one instead of two distance senses and the lesser one at that, since sound does not begin to function as a clue to the presence of an out-of-reach object until late in the first year. Evidently a child who is born totally blind cannot make use of distant sound cues from an invisible object any earlier than a sighted child. Ironically, he remains in a void until he can make his own direct contacts with the external surroundings; until he has an incentive to move into those surroundings he cannot discover their existence. Once reach on sound has been achieved he can be lured into motion and can begin to cope with the relatively less difficult problems of balance, coordination, speed and safety.

If the blind child is provided with good mothering and the chance to become familiar with many body positions, and if his hands and ears are given months of varied play experience with toys that unite tactile and auditory qualities, he will have found interest and taken pleasure in the space immediately around him. He will then be ready to move forth into a larger space when he becomes aware of the interesting possibilities just beyond his reach.

## SUMMARY

The gross motor development of ten infants blind from birth was

observed from birth to two years. There was a regular pattern of development for the blind infant, but it differed from that of the sighted infant. Adequate neuromuscular maturation was demonstrated throughout the first year in the postural items which all occurred within the sighted age range. But there was a considerable delay in self-initiated mobility. We infer from the delay in self-initiated mobility that vision must play a more central role in the achievement of mobility than it does in the establishment of stable postures.

Vision provides the sighted child with a lure, an incentive at a distance. Early eye-hand coordination enables him to reach out for what he sees and wants. Eventually trunk and body extend the reach of the hand and the child moves from one place to another in pursuit of what he sees.

Ear-hand coordination, i.e., reach for an invisible object on sound cue only, normally occurs late in the first year for the blind child as well as for the sighted child. Until sound at a distance can provide a lure, until the blind child is reaching out for and seeking what he hears, he remains immobile in sit or in stand. Only after he has become practiced in *reaching on sound* will he begin to creep and walk, slowly mapping the concrete world around him.

The prolonged period of immobility during the first year of life represents a serious threat to the ego development of the blind child. It lessens his ability to explore independently, to discover by himself the objective rules that govern things and events in the external world. In an intervention program based upon uniting sound and touch, first centered in the child-parent pair, and later in the play experiences given the child, we were able to decrease the interval between postural achievements and mobility in comparison with another group of blind infants. At present, however, it seems unlikely that the delay can be completely eliminated since sound does not provide the same adaptive advantages as sight.

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# PRESENTATION OF FILMED MATERIALS ON MOTOR DEVELOPMENT OF BLIND CHILDREN

## INTRODUCTION

### An Atypical Sample

In introducing the filmed records Mrs. Adelson reminded the audience that this was a special group of blind children, and it was not representative of the blind population as a whole. They had been carefully screened before being included in the research group and had no other impairments. These children were diagnosed as totally blind at the time of admission to the research unit, although some of them did have light perception, and at a later age a few showed color perception.

The children came to the project early in their first year. Consequently, another way in which this sample was unique was that intervention was offered almost from the beginning. Their families had help very early in their children's lives. The aim was to optimize the possibilities for healthy development so that in evaluating the data it would not be necessary to account for other kinds of deprivations in addition to the major sensory deprivation. Comparison with records of the group of 66 blind children studied by Miriam Norris and her co-workers shows a growing divergence between these two groups, with the Ann Arbor group a year ahead of the Chicago group by the time they are walking. Mrs. Adelson felt that this confirmed that lags shown by their group of children in certain specific areas were due to blindness alone.

## VIDEOTAPE PRESENTATION

A seven-minute videotape was then shown. This showed three of the children at a slightly older age than had been discussed in the paper. They were seen in rather active scenes, using their bodies spontaneously, moving through space. As Mrs. Adelson pointed out, the videotape sequences showed how the children felt about

their bodies, and themselves, the pleasure they took in gross motor experience and how they made use of the people, the furniture and the geography of the space in which they found themselves. The first videotape sequence showed Karen playing outdoors with her sister. She was jumping down the back steps and running across the yard. Karen was 3 years, 9 months and 24 days old at the time and is blind due to retrolental fibroplasia. In her second year it was found that she had light and color perception, but no form perception as far as can be determined. The second sequence was of a 3 year, 10 month and 17 days old boy, Paul, visiting the project playroom. He was climbing up the jungle gym and going down the slide. His blindness is due to infantile glaucoma. He too has light and color perception, but no form perception. The last segment showed Elizabeth, at the age of 5 years, 9 months and 18 days, in her regular kindergarten classroom. She was marching in the rhythm band, keeping the pace and pattern by herself. She is totally blind due to retrolental fibroplasia.

At the present time (April, 1972), all three children were in school, two of them in public school situations.

### Aims of the Study

Mrs. Adelson pointed out that interest in gross motor development was always imbedded in the larger longitudinal study, which included many other areas of early ego development. They were therefore less concerned with specific gross motor achievements and skills than with observations of the unfolding of the entire gross motor sequence as it related to human attachment, or prehension, or language development. It was always being seen in the context of its effects upon the other areas of development and the ways in which those areas were affecting the unfolding of gross motor development itself.

There was no curriculum, no training of particular skills.

Specific Problem  
Area Identified

A notable feature of the gross motor development of these children was that posture, the balance of head and trunk and even alternate leg movements--as when a child's hands are held and he is encouraged to come forward--all fell within the sighted age ranges. One may infer therefore that vision does not play a major role in the achievement of these. However, there were notable delays in the achievement of what may be called self-initiated mobility, steps or shifts of posture that a child undertakes on his own, usually because there is something or someplace "out there" that he wished to obtain or approach. It was at this point that the lack of vision became a dominant factor. It became evident, in watching these children, that if the problem was not in the maintenance of posture or the movement of body parts, it had to be in some sense in the links the child was making between himself and the objects in the external world.

## FILM PRESENTATION

The film which was shown at this point showed two children between the ages of five months and one year, progressing through this phase of gross motor development. Mrs. Adelson pointed out that clues to the process involved could be found by watching the hands of these children. They were putting together the pieces of their experience when the ordinarily smooth synaesthesia of the senses, to use Werner's phrase, had been disrupted by the lack of vision. What was heard could not be connected with what had been touched; and what was touched and handled could not be connected with what was only heard. This seemed to be the major hazard to gross motor development at this stage. The children could be seen almost literally wrestling with the problem of what a sound "out there" might mean and whether they could do anything about it. Among the objects handled by the children in the film were sound-producing ones, bells and a toy dog with a built-in music box.

## Reaching-on-Sound Cue Absent

The first film sequence shows one of the children, a boy blind due to hypoplasia of the optic nerves, at 7 months, 10 days of age. He showed preference for the toy dog over other objects, was distressed when it was removed and grasped it eagerly when it was put back in his hands. About a month and a half later, the same child was still not capable of reaching out for the toy upon sound cue alone. It was evident that he heard it, and his hand movements indicated that he knew it could be held and wanted it, but he was not yet reaching out for what he heard. He also did not shift from a sitting position to a creeping position in order to approach what was being removed from him. Another sequence showed this boy rising from a prone position to balance adeptly and vigorously on all fours. This left no doubt that at this age (10 months, 9 days) his motor capabilities and balance were adequate to the task; nevertheless, he was not yet moving forward on hands and knees toward a goal.

The child was then, and had been for several months, getting experience in handling objects which united sound and touch. He held his dog as it played its tune. He manipulated and explored a bell and made it ring himself. However, upon hearing only the sound, he still did not identify with the object he had touched unless it was in exactly the same spot he had played with it last.

## Reaching-on-Sound Cue Achieved

Signs that he was putting together the sensory experiences from the two modes of sound and touch came at 11 months. The film sequence from his visit to the research unit at this time showed his response when the bell, which he had not yet handled that day, was sounded. At first the movements of his hands gave some indication of what he was thinking as he sat on the floor. He then lunged forward and for the first time, managed to reach out into space and grasp something he had heard. He immediately rolled over on his back with a radiant smile and started to ring the bell.

### Self-Initiated Mobility Appears

Three days later, this child's family called to announce that he had crept across the living room floor for the first time. The final sequence of the film devoted to this boy shows him engaged in this activity several weeks later.

### Analogous Development in Second Child

The second part of the film recorded an analogous sequence of development in another boy whose blindness was due to infantile glaucoma. This child had light perception but it did not seem to affect the unfolding of these particular events. The first sequence of the film showed him at five months of age and illustrated his dislike of being placed on his stomach. This was typical of most

children in the sample. It was not a pleasant or useful position since there was nothing for them to see or do. He was shown again at 8 months of age by which time the bell had taken on meaning. He was not quite ready to put together that meaning with the availability of body mobility. He wanted the bell and was very attentive to the sound. It could be seen from his hand movements that he recognized it as the bell he had held and rung in the past. He made shaking motions with his hand, as if ringing it, but he was still not attempting to get to it. At ten and a half months, he was beginning to put together his more capable body and the bell "out there," but had not quite mastered all the mechanics. The idea was there and could be seen in his hands, as Mrs. Adelson pointed out, in the way one would ordinarily see it in the eyes and face of a sighted child. Soon after this, this child also crept across the floor for the first time.

*Editor's note:* The interested reader will find a more comprehensive discussion of this material in S. Fraiberg, B. L. Siegel and R. Gibson, "The Role of Sound in the Search Behavior of a Blind Infant," *Psychoanalytic Study of the Child*, 1966, 21, 327-57.

My work is with developmental care and stimulation programs in day care with normal babies, starting sometimes at two months and continuing to five years of age. I will comment on a few points of methodology; some issues and ideas about development with sensory deficit and its relationship to developmental outcome; and methods of program, stimulation, and care.

## METHODOLOGY

The approach used in this study has been interesting because it combines experimental approach with individualized observations. It observed the details of the activity in terms of analysis of the tasks, and the child's efforts toward success. What is partially lost in experimental rigor is more than made up for by the effectiveness of a process approach. One of the problems of much experimental research has been that the child and the perspectives of development are lost in the abstraction of variables. There is the problem of assessing the nature of a developmental problem and intervening so that the character of the phenomenon you are investigating changes in the course of the work.

I am familiar with this problem because it happens in my own programs. We begin by making an assessment of the babies. The next step in the timetable is to introduce a treatment. The nature of the treatment evolves constantly, and we do not adhere rigidly to a plan. Adaptability is practiced in the interest of the welfare of the children.

The developmental perspectives that come from observing a series of tasks, where we see more than the relationship of a child to just one task or a short set of trials as in traditional work, is also interesting. The developmental perspective led to

the insight into the fundamental distinction between the blind child's ability to develop in terms of postural control as compared with his capacity to initiate mobility and move out into the world.

More details of some of the particular events in the children's lives, probably available to the authors, but not included in the paper, would have been most helpful.

Four of the children had some residual light and color perception. It is not clear whether or not it made a difference for any of the children. Was there a test to see if there was any figure ground perception later on, as distinct from only a very vague blur of light? It appears that this might be a critical issue that would influence the development of this subsample as opposed to the totally blind group.

The paper gives a rather interesting perspective of how their sample compares, first with sighted children generally on the basis of norms for a large population; and then with a larger sample of other blind children who, however, have known differences in their characteristics. There is a contradiction here. On the one hand you might expect that the totally blind sample would do less well than the Norris sample which had a greater proportion of children with light and probably form perception. On the other hand a greater number of the latter were premature, and it is hard to consider this in terms of the general pattern of development of the three samples. Although this was the most visually deprived group, the Child Development Project sample apparently had less handicaps, and presumably were getting much more adequate care and stimulation.

Yet there is not a decisive picture of three samples, ranging from sighted to moderately to severely visually impaired to totally blind, and how they fit into the

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\*University of Toronto.

results. Instead, there is the contradiction of the Child Development Project sample doing better than the Norris sample, presumably because of the cumulative effects of intervention. This is, of course, gratifying to see from a humanitarian as well as a scientific point of view.

One thing that confused me was the fact that the children were first seen and assessed at ages ranging from one to eleven months of age. Yet in Fig. 1, data was reported on as many as eight to ten children throughout the age range. The question of how such a complete assessment of the children was attained was subsequently clarified by Adelson and Fraiberg.\*

I am not quite persuaded as to the gross distinction made between postural development, postural control, and self-initiated mobility, inasmuch as there are no statistical comparisons. By visual inspection one can see that there are some differences in all of the items. There are three of the self-initiated mobility items which seem to be rather closer

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\*The data in Fig. 1 involved corrected ages. Three of the children were three months premature, so that an eleven-month old child appeared as eight months old. Doctor's reports of achievement were accepted and also parent reports of a few achievements. However, specific observations on the others *were* made. An eleven-month old child moved back to become an eight-month old child in the corrected ages, was shown in a photograph at an earlier age to be sitting, which was felt to be an acceptable piece of data, as opposed to parents' report of what she might or might not have done.

In addition the ages were corrected for prematurity for comparison with the sighted norms, but were not corrected for comparison with the Norris group because Norris did not correct for prematurity. There is a disparity here that had to be accommodated to the systems employed.

to the sighted age range. In fact, there is distinct overlap here. One of the items included among the postural ones is "rolls from back to stomach," and I find that a bit of an enigma. Two others, "raises self to sitting position" and "pulls up to stand by furniture," seem also to be closer to the postural ones.

## DEVELOPMENT AND SENSORY DEFICIT

Moving on to issues of development itself and sensory deficit, it is striking, though it has been a cliché in psychology, how much our world is visually regulated. From the study it is most impressive to what extent information about the environment and our ability to exercise autonomy in it is governed by visual contact. This brings to mind all the current work on early experience and development and learning, and the value placed upon intrinsic motivational systems and the importance for development of visual-perceptual matches with perceptual-cognitive schema. It is an entirely different world, obviously, for blind children, but it is also a whole new world for me to think about in understanding what happens to children's development and how it is regulated.

It is interesting how the cognitive schema are so dependent upon perception and stimuli from the outside world through vision, and is well illustrated here in gross motor aspects of development. It is again the visual pull, or lure, of incentive at a distance which provides the mechanism, or an essential mechanism, by which the child is led to move outward, to develop his controls in the gross motor systems. Once he gets to the new position, from prone to sitting to standing to walking, he then has additional vantage points from which to survey, to see and explore a variety of new spectacles. This is what is so much more difficult for, and so lacking in the blind infant.

In one sense, it is rather depressing that the role of the auditory medium cannot equal that of vision as a substitute in adapting. Some hope may be taken from your

work, particularly from the cumulative effects, and how much these children did finally diverge from the Norris sample. Also, they were able to be socially integrated into a normal population of children. It indicates how less precise and less differentiated the world is by auditory cues than by visual ones. I suggest that auditory modality does not provide an adequate substitute, since much of the world is a silent one. Many if not most objects in the world carry no noise value, no sound-discrimination value. Tactile, manipulative, and kinesthetic aspects will have to be relied upon a great deal more.

### SPATIAL DEVELOPMENT IN THALIDOMIDE BABIES

I was asked to compare and comment on the thalidomide babies. Retardation of spatial development in these babies seems to be one of their handicaps. We have to treat the data on this with some caution because analysis by severity and type of defect is slight. It is not clear to what extent it is a function of the particular tactile deficit involved, or the apparently greater trauma that these families experienced, and the consequences to emotional and ego development of the child.

Nevertheless, these children are more retarded in concepts of abstract or projective space; that is, the ability to see space at a distance and be able to orient from a number of different vantage points to how other people perceive objects in space; to be able to treat conditions of physical objects in space reciprocally with other people's points of view. Their performance in proximal space compared favorably with average norms. Again, this is in the absence of knowing exactly which limbs were deficient in which children. It is not clear why this abstract concept of space would be lacking when the vision was normal. It should also be noted that the children in Dr. Decarie's sample were older than the blind group described in the paper.

The degree to which mobility was impeded was not indicated in the

material to which I had access. They received prosthetic devices of various kinds gradually. Presumably there were many of them with deficient or defective limbs, particularly the upper extremities. Tactile experience, manipulating with the fingers, the critical aspect of exploratory processes were the ones most affected. Why this would not result in proximal space deficits but would result in deficits in abstract space is something that I cannot conceptualize, except perhaps that in the blind sample fine-motor development was more or less adequate. I wonder if they were as adequate in terms of generalized problem-solving processes requiring fine-motor actions: object retrieval, form boards, building towers of blocks, box-opening problems; the sorts of things that involve problem solving rather than just object manipulation.

Certainly one of the interesting theoretical problems relative to the development of the blind child is one of how he develops the schema for object concepts. Even to measure object-concept development presents a real challenge. I tried to think of ways of establishing complexity equivalents to the series of visually regulated Piaget-type tasks. The object concept is assessed in the progressions of a child from a few months of age up to 18 months or so in being able to follow objects visually; in following partially disappearing objects; in searching for absent objects; in looking for absent objects or disappearing objects in a displaced position, visibly displaced; and finally, following objects through a series of invisible displacements. How do we assess this in a blind child? We can perhaps think of auditory discrimination tasks and disappearing sounds; perhaps even having objects that make a sound immured in boxes to prevent the sound from being heard. Or, we can move to another mode of assessment, the tactile medium, and think about the child following disappearing objects that go partly out of reach and then completely out of reach, and then through a series of--how do you have "visible" displacements as against "invisible" displacements when everything is invisible, when the very term is obviously perceptually geared to the visual world?

Exploring this problem would certainly be worth some research. One might engage more in training for assessment than in the past, having the child experience following the hand of the tester around objects and getting used to having objects placed in things, and then setting up expectations for the child to explore. Yet in the very course of doing this, the child is given more sophisticated kinds of perceptual experience, and you are caught in a dilemma. The operations needed to test the child are those that are likely to develop the object concept; object permanence itself. Not much can be done about this problem with blind children.

### TACTILE-KINESTHETIC INVOLVEMENT

There is need to mention here that the auditory world as opposed to the visual world, and particularly the tactile, does not involve the same kind of active engagement. The sound goes on and off and does not entice the child in the same way. It is necessary to involve the blind child in a tactile-kinesthetic medium because of the active manipulative contact. Whereas he has no point-to-point control over the auditory world, he does have control with his tactile contact in the way that sighted people do with the visual world. By our own initiative we determine contact with the visual stimulus world. We cannot do this with the auditory medium. The auditory medium comes and goes according to the nature of the phenomenon, but the visual phenomenon remains there stable and solid in space. In this way we have a direct, active experience in regulating our own movements and contact with the visual environment.

### PROGRAM COMMENT

More details of the program at the Child Development Project would be most welcome.

We need to determine the areas in which a blind child could reach normal levels of competency, perhaps even surpass normal levels, could attain those optimal levels of ability that would have occurred if he had not been visually deprived. The

benefits would be felt in all spheres, not only gross motor or fine motor, but also spatial concepts, language, and, in general, cognitive, problem-solving, and creative processes. Think of two aspects of care and stimulation. One is that of prevention and the other is of compensation. Inevitably, the compensation is involved at every level in every program, by virtue of the fact that you are compensating for visual deficits as well as "compensating" in the sense of intervening later on, systematically, because the child has been isolated for some period of time. This is happening less and less in the world as we become more sophisticated in developing institutions to provide early contact with professional programs.

Evident in the program is the physical intimacy, the various efforts to engage the child in a rich variety of perceptual experience in the modalities in which he is not deprived. There is certainly evidence that the program produced good effects, and in the long term, cumulatively, we see rather fine results. Whether it occurs with every child, and whether this is related to how early the child came into contact with the program and the child had the benefit of guidance is an interesting and important question. Extreme cases often reveal the most valuable information. In fact, many of the Project's extreme cases were at or within one month of the sighted median on all but one of the items in the gross motor sphere.

We have long assumed, in the gross motor sphere in particular, that this is largely maturational. McGraw, in the 1930's, made a fundamental distinction between the ontogenetically- and the phylogenetically-based skills. The phylogenetic skills being those that are subject to rather heavy biological overlay in development, the gross motor sphere in particular: posturing, sitting, walking, and so on; and the ontogenetic being those that involve learning. Yet, I came across an interesting observation on infants in Uganda by Cole et al. in a book, *Cross-Cultural Study*, in which he reports that many of the babies he observed were walking at five and six months; a rather startling thing. I have seen in my own experience one child who walked

at five and one-half months, and this may have been an exception. But, if in a particular culture quite a large proportion of the babies are walking at five or six months, it does raise the question of causation.

Cole observed that on the day of birth, the child was placed on the mother's hip, and had no control of his head. However, soon he was controlling his head out of desperation, and the wizened little creature was getting along fine. Is experience producing this unusual development, or is it perhaps a particular genetic factor?

Certain general principles used in my work should be considered in work being done with blind children. There is a rich variety of sounds for them to listen to and objects for them to explore. Were these activities graded in difficulty? Did sounds change in direction and orientation, move on the proximal-distal variable, vary in type? Were preference values of musical tones versus noise established?

## THE TOY ENVIRONMENT

In laying the groundwork for readiness, particularly for the very young baby at the point where a normal baby is beginning to reach, or even before, a toy environment could be created; an object environment in a confined area with clear boundaries. The floor could be sloped toward the baby in the center, so that the toys would tend to come to him. Then gradually the floor could be flattened so that the toys would tend to stay away. Experimentation could be done with the texture of the surface and the degree-of-slide of the toys.

For the tactile exploratory process the organizational arrangement of toys, placing them in different positions, first immediately in front, then to the side at varying angles, supplies enrichment by systematically providing a great variety of these operations not of distance alone. This is important in the beginning, in the baby's first few months. The fact that you did not have all your babies from their first

month undoubtedly accounts for some of the residual differences between your group and the sighted children.

## SIGHTED PEERS

There is nothing like another child, particularly a slightly older child who is already a little more developed, to serve as a model, a source of stimulation about the nature of the object world. One combines, of course, the social and the physical world here, enriching the child's experience greatly.

## LANGUAGE

In the area of language, the problem is greater with the blind child. One has to be very careful to coordinate language statements to the child with tactual examination of the phenomena. A mother takes for granted that the sighted child sees the object at which she points. Not so with the blind, unless we make a point of offering the object for exploration every time we label it. This gets into the problem of syntax later on. When you are dealing with a description of movement, of events, of processes--and this is much more complex--how can the blind child deal with this phenomenon tactilely at the same time it is being described? This is a critical aspect of language development--that language be related to reality.

## GROSS MOTOR ACTIVITIES

Special apparatus to develop gross motor skills should be designed and built. Climbing apparatus, an inverted V to climb up one side and down the other; two-child equipment used jointly, such as miniature teeter-totters should be developed so that there is the experience of controlling and being controlled jointly and interactively.

## AUDITORY VS. TACTUAL

In the work presented, there was great emphasis on the auditory. I suggest that the stimulation of the child by placing objects just within

reach, then partly out of reach, and gradually changing position would map the physical world for him more rapidly than the auditory experience would. In the tactile world as in the visual world, everything can be mapped, but an accurate map of the world cannot be provided through the auditory modality.

## GENERAL DISCUSSION

### ENRICHED TACTILE-AUDITORY EXPERIENCE

In response to Dr. Fowler's comments and his suggestion that additional details on their program would be welcome, Mrs. Fraiberg said that "sound" items were selected in their presentation in order to show that sound would not serve as a lure for a child at certain ages. However, very rich tactile-auditory experience was also provided in the program. The creation of what they called an interesting space for the blind child had been described in earlier papers. This was done in ways that largely coincided with Dr. Fowler's suggestions. At the earliest age a cradle-gym was provided until the child was able to support his trunk. Then, when he was able to sit, at first with support and later independently, the child was provided with a play table and a small number of objects. During play these were displaced, so that he would find the same object in different locations at different times. Still later, when the child began to pull himself up to stand, a playpen was provided. This would not have been done for a sighted child, but in the case of the blind child it was provided for just such reasons as Dr. Fowler had mentioned: to create a space which he would be able to explore with his limited mobility, and in which he would find objects and be able to recover them.

### OBJECT CONCEPT

Regarding object concept, Mrs. Fraiberg said that the problem of translating the Piagetian task for blind children had occupied her team for years. At one point they felt that they had succeeded. In fact Piaget himself, after watching the film of the procedure, was satisfied that the Stage VI test they had devised was a good one. Later they began to question their success, although on re-examining the same film recently Mrs. Adelson felt it contained remarkably good evidence for the achievement of Stage VI. The child involved was two years five months old. If one were willing to

credit the performance as Stage VI, this would, therefore, be a considerable delay over the sighted norm which Escalona now puts in the range of 9 to 25 months (with 17.2 months as the median). Mrs. Fraiberg considered that the whole question deserved special investigation. Unfortunately her group was too deeply involved with the study of so many aspects of development to be able to pursue this one topic sufficiently. It still needed to be done, once the problem of equivalence of task was resolved.

## LIGHT PERCEPTION AND COLOR

Mrs. Fraiberg reported that light perception and color seemed to provide little or no advantage in locomotor achievements in the first year. However, in the second year there were great advantages in prehension, because the child began to infer from the color patch. Color then became a target for the child. She underscored that it was fairly certain, on the basis of figure ground tests, that these children were not discriminating form. As for light perception, the shadows could reveal movement, so that an elementary concept of movement became available to the blind child with light perception through shadow play.

Mrs. Adelson added that the children with light perception tended to be in the first half of the sample, but that was all one could say. The group was very small and various other differences should be kept in mind: who came in first when the research team was less experienced, and who came in youngest, who was in the program for the longest period of time, who had light perception, who had the most stable family, and who had the least stable family. There were girls and boys, prematures and full term babies. There were hints, but nothing firm enough to justify drawing any conclusions.

## SUBJECTS

Mrs. Fraiberg pointed out that there were unique problems in setting up a sample. The babies are rare. In an area of 50 to 75 miles outside

of Ann Arbor, the children described in the paper were the only babies they had seen who satisfied the same screening requirements at one year and two years of age. It sometimes happened that a child had more vision than had been assessed, or actually had a CNS impediment that had not been evident. Those children of course had to be quietly and tactfully moved into the educational program. They could not be included in the research sample. The age at which they were referred was also a problem. Many pediatricians still do not know that a baby can be tested for tracking very early, so babies were being referred at five and six months who could have been diagnosed much earlier.

## Observation

Equally important were problems of experimental rigor due to the lack of observational procedures that could be established ahead of time. They had to be developed and varied as the research team's experience grew. There was also a lack of adequate instruments for the assessment of these children. The assessment instruments for a blind population have certain limitations in any case, especially because of the variability within that population. There was nothing available for this rather special sample. All that could be done was to observe and record and classify, knowing that if the experiment were to be done over again many things could then be done that could not have been done originally.

## ASSESSMENT

Dr. Chess commented that when she and Dr. Fernandez began evaluating children with congenital rubella, the whole question of assessing youngsters for sensory deprivation opened up a new world. They had assumed there were methods and instruments available but found that this was not the case. Mrs. Fraiberg's study had been of considerable importance to them. In the present discussion she was struck by the number of similarities, in this beginning of an assessment, of the effects of a single sensory deprivation. Consider, for example, some of the studies that have been trying to assess the effects of

malnutrition. They are similar problems, even though they are worlds apart in many ways. Here, as with the congenital rubella children, the question is how do you set apart the sensory deprivation of the visual organ in the multi-handicapped. Even in the children who have only the visual sense organically deprived, there is a difference between the Fraiberg and Adelson sample and the Norris sample. Here one would suspect, as with some of the children in the rubella study, that not only was the organically-impaired sense deprived, but that parents lacking special guidance in effect deprived other senses too.

There were also other issues involved, Dr. Chess said. For example, she was very impressed with the amassing of the Norris sample of children with retrolental fibroplasia. To pick out the ones whose eyes only were affected, and not those where the excess oxygen had caused brain injury was a whole problem in itself. Perhaps once the data accumulates one can have a series of developmental stages, or perhaps several series: one for visual deprivation only, another for organic-visual deprivation with some of the experimental deprivation that would ordinarily be the case. When selecting a chart of developmental milestones it would then be a legitimate question whether to use the Norris chart or the Fraiberg chart. In evaluating children who had never had the benefit of the kind of guidance that the Child Development Project provided, perhaps the Norris chart would be the one to use. It would give the normative expectation indicating whether a blind child in fact was lagging behind the expected acquisition of motor milestones. The Fraiberg chart would be a gauge of optimal development if one wanted to evaluate the adequacy of a remedial program. In their own study there was also the question of whether there was auditory deprivation besides visual deprivation, and all of the other issues. In that group it was virtually impossible to find a child who had visual deprivation only, because by the time the congenital rubella reaches the visual apparatus, it has affected two or three other areas too.

## HETEROGENEITY OF BLINDNESS

Dr. Parmelee emphasized the heterogeneity of blindness. This was a topic that had come up repeatedly in various forms during the discussion. He felt it might help to clarify why one could not just talk about the "blind" child, citing some examples.

Congenital glaucoma, for instance, is peripheral and the brain is not involved. However, the resulting blindness is a progressive problem of the cornea, so the child might have reasonable vision, or at least light perception, for quite a while, and only later become blind. But vision might be completely gone by the time such children were 3 or 4, when definitive testing became possible, if the surgery has been unsuccessful.

Optic atrophy is a general diagnosis for the ophthalmologist and has many causes. The child is considered blind because he is not functioning well visually as an infant; but there can be some visual function, some input, which over time and with cognitive development, might be used successfully for some level of visual discrimination. Rubella children are almost never completely blind in the true sense. Even those who are eventually blinded have cataracts which developed progressively over time, so they have experienced quite a few months without visual loss.

Children with retinoblastoma also have a period of vision before the tumor obscures vision or the eye is removed surgically.

The anophthalmic child is of considerable interest because the absence of the eyes is evident at birth, the mother is aware of it, and the specialists become involved early. But since the eye is an outgrowth of the nervous system itself, anything that interferes with the development of the eye may affect the nervous system as well.

The absence of neurological findings does not necessarily guarantee a clean sample. There are mentally retarded children due to

organic brain disease who have no other manifest neurological findings.

There is no way to arrive at a homogeneous sample of simple blindness especially in early infancy.

## EARLY DETECTION

A few mechanical things can be done. An electroretinogram can be done fairly early indicating whether any retina was spared. In the retrolental fibroplasia cases the scarring process is progressive. Even where it is complete there could be some residual unscarred retina, and these children are never blind from birth. So an electroretinogram done as early as possible could show if there was any retinal function. Testing for a visual-evoked potential could show if there was anything going over the pathway to the cortex. All this, however, still did not provide a complete picture.

It may come as a shock to some, Dr. Parmelee said, but there was no ophthalmologist who could test for visual acuity until he could use something comparable to the E chart. Some have tried, for instance, by rolling balls of progressively increasing size at a distance from the child, but one can really only determine how the child performs in vision, and this is not a substantive issue. So for these many and various reasons one inevitably has to deal with a very heterogeneous group.

Dr. Bach-y-Rita agreed with Dr. Parmelee, and felt this was a point that should be emphasized. There was practically no way to determine congenital blindness unless there was an absence of eyes, and the issue was currently being debated in ophthalmological circles. There were techniques being developed such as refraction by evoked potentials, but these had not been applied to very young children. Eventually they may be refined sufficiently to do so. He estimated that probably 95 percent or more of those now classified as congenitally blind were not really congenitally blind.

Dr. Friedlander added that where there was residual visual sensitivity,

it might be very important to be able to identify it. The visually-impaired people with whom he had talked about this reported that the impact of what little light experience they had in their early childhood was of tremendous importance. And usually it had been a very negative experience because the adults in the environment did not understand the nature of that impact on their adaptation.

## FACIAL EXPRESSION

Turning to the visual part of Mrs. Adelson's presentation, Dr. Prescott said he had been struck by the phenomenal lack of emotional expression in the infants who were given toys when still at a stage of not being able to reach out to get hold of these toys. He contrasted this with his own 10-month old child who was a bundle of joy and pleasure. The blind infants, even at 10 months of age, presented completely flaccid expressions, so that when they handled a toy there was no smile. However, he recalled that in the film "Rock-a-bye Baby" one of the blind children from Mrs. Fraiberg's group who had received extensive touching and handling appeared to be just the opposite in emotional expressiveness. This child was three years old, and there was no indication of a social or emotional effect of the impairment.

Similarly, it was also illustrated in "Rock-a-bye Baby" that a *sighted* institutionalized infant of 6 months age could not sit upright by itself nor show any positive emotional expression to a rattle that was presented to it. These behaviors were completely reversed with a personal caretaker who touched and handled the infant extensively. These observations support the point of view that disturbed affect in blind children is not due to their blindness but rather to concomitant somatosensory deprivation.

Dr. Parmelee interjected that Dr. Prescott was trying to read the face, and there was nothing there in the face. But this was not due to the child's lack of emotion. He expressed his emotionality in many ways, but not necessarily in the nuances of facial expression which were what Dr. Prescott had looked for. The smiling

was there, but without the same nuance, which these children had no way of learning. Mrs. Fraiberg agreed that if one were to read faces, those modulations of expression that we normally read on an infant's face were simply not there with the blind. But that, she felt, was also indicative of how much of the emotionality of the face is responsive to the stimulation of vision and also how much has been differentiated through reflection and through imitation already in the last quarter of the first year. With the older children one sees more modulation of expression. She felt that Dr. Prescott was quite right on that point.

### ACTION, AFFECT AND MEANING

The point that Dr. Prescott wanted to emphasize in this regard, however, was *when* the blind children started to smile while holding an object. It was when they had initiated their own movements, that is, when they went out after an object. Their faces did not have smiling expressions when they just had the toy, but when they were able to reach out or move across the room and grab hold of it, there was a distinct smile. Whether this is typical or not, he could not tell. However, Mrs. Adelson had talked about the object having meaning to the infant. It seemed to Dr. Prescott that the object did not have meaning prior to the point when the child was able to initiate his own movement, and associated with this, at least in these sequences of film, was the smiling response.

What he was trying to suggest, admittedly from a few cases and from very limited information, was that the affective component was crucial to the blind child for the acquisition of meaning of objects. In his opinion one had to talk about the affective component of meaning as well as the cognitive component.

### GROSS MOTOR DEVELOPMENT

Turning to the question of motor development, Mrs. Fraiberg said the data from Uganda raised an interesting point. She understood from Dr. Prescott that there was additional material by Lederman at Stanford subsequent to the study mentioned by Dr. Fowler. It shows that not only are these children terribly precocious, by American standards, in gross motor development, but once the child rearing practices become westernized and they borrow our own practices in infant rearing, the accelerated gross motor development is no longer evident, and they begin to look like our own babies. Dr. Friedlander commented that this was very important from a conceptual standpoint, because a few years ago people were saying that a genetic factor was responsible. Dr. Prescott added that unfortunately they were still saying it. He considered infant carrying practices to be one of the major issues for the assessment of infant precocity which has a number of implications for specific childrearing practices.

## Second Session

### A COMPARATIVE STUDY OF THE EFFECTS OF EARLY BLINDNESS ON THE DEVELOPMENT OF AUDITORY-SPATIAL LEARNING\*

Formal Presentation: Manly N. Spigelman\*\*

It is evident that the visual system in all but the lowest of mammals is inextricably bound up with the total developing organism; it is profoundly integrated not only with the infant's other sense modalities, but also with posture, motor skills and coordination, and even personality structure and intelligence. It is not surprising, therefore, that blindness in humans has frequently been shown to result in a wide variety of non-

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visual perceptual and learning disabilities, and that the impairments are often found to be most pronounced in subjects blinded either at birth or shortly thereafter. For example, it has been observed that congenitally-blind humans are frequently inferior in maze-learning ability (Duncan, 1934; Knotts and Miles, 1929; Koch and Ufkess, 1926), as well as in other more complex tactual and auditory learning situations (Axelrod, 1959; Ewart and Carp, 1963; Worchel, 1951). In such tasks, sighted subjects generally perform more proficiently than those in whom the onset of blindness occurred some time after birth; the late-blind subjects, in turn, tend to be similarly superior to the early-blind subjects.

A number of animal studies have also served to demonstrate the importance of the age at which a particular condition is experienced, as well as the nature of the condition itself. Early enriched visual stimulation, for example, as opposed to the same treatment at a later age, has been shown to improve animals' performances on several perceptual and learning tasks later in life (Bingham and Griffiths, 1952; Myers and Fox, 1963). Conversely, early visual deprivation has generally yielded the opposite effect, severely retarding later efficacious perceptual behavior (Riesen, 1947; Riesen et al., 1964). However, the few data available concerning the effects of early blindness on maze-learning in animals have been equivocal. Hebb (1947) reported adverse effects on maze performance by rats which had been peripherally blinded by enucleation shortly after birth. A similar trend was also

observed by Hymovitch (1952), although the results failed to achieve statistical significance. Mahut (1965), on the other hand, could discern no differences between late-blind and early-blind animals when tested on the same task as that employed by Hebb and by Hymovitch.

Several approaches have been adopted in attempting to account for the performance deficits of the early blind. One suggests that the impairments result from a failure to develop the visual schema essential for dealing with a predominantly spatial world (McKinney, 1964; Sylvester, 1913; Worchel, 1951). Others, such as Axelrod (1959) and Hebb (1947, 1949) have alternatively proposed that the early-deprived organism fails to develop general learning sets, and is consequently unable to deal with a complex environment.

The present studies also deal with the effects of early *versus* late blindness. They attempt to examine whether early visual deprivation produces a specifically spatial-perceptual impairment, or, on the other hand, a more global intellectual or learning deficit. Employing both humans and animals, the research centers about the ability to localize a sound in space, and attempts to deal with the following questions:

1. Does early sensory deprivation produce a general learning deficit in the rat, or is the impairment manifested only in specific kinds of learning situations? Two of the experiments deal with this question.
2. To what extent is adult emotionality affected by infantile blinding?
3. What effects on auditory-spatial development, if any, are produced by prolonged blindness?
4. Are the impairments observed in rats resulting from early sensory loss generalizable to higher species, such as humans?

## EXPERIMENT I,<sup>1</sup> SPATIAL-AUDITORY LEARNING

This experiment attempted to compare the performances of early-blind, late-blind, and sighted rats on a spatial-auditory learning task. The task entails the ability to localize and respond to the source of a sound, and was chosen for two main reasons: first, it appears to be a difficult one for rats to learn (Munn, 1950), and hence might effectively discriminate between the handicapped and the non-handicapped. Further, the spatial component involved has frequently been implicated in the impairments observed in early-blind humans.

### Subjects

Twenty-seven albino rats, comprising two litters, were randomly divided into two groups at ten days of age. All pups were individually anesthetized with ether, and six males and six females were peripherally blinded by enucleation.<sup>2</sup> They were then returned to their respective mothers, and left until weaning at twenty-one days of age. After weaning, males and females were separated and placed in colony cages. At approximately ninety days of age, all *Ss* were again individually placed under ether anesthesia, and six males and four females were enucleated. Three males and two females remained sighted. Following the operation, each *S* was numbered by earpunch, placed in a standard individual laboratory cage, and allowed food and water *ad libitum* for ten days.

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<sup>1</sup>The data from Experiments I and II have been reported elsewhere by Spigelman and Bryden (1967); Experiment III was very briefly discussed in the same article. Similarly, Experiment IV has been described elsewhere by Spigelman (1969). The research particularly relevant to the present conference (Experiment V), however, has not been previously published.

<sup>2</sup>A detailed description of the blinding procedure may be found in Spigelman (1968).

Before testing, all records of each *S*'s treatment were given to someone not directly involved in this or any subsequent experiments. In most cases, *E* was unable to discern a physical difference between early-blind and late-blind *Ss* (late blind-tends to be *slightly* neater). Hence, the experiments are reasonably free of "experimenter bias."

### Apparatus

The apparatus consisted of a modified form of the Y-mazes employed by Muenzinger et al. (1931) and Pennington (1938) (Fig. 5).

The screen-covered start box and arms of the Y-maze were 6 inches wide and 12 inches high. The start box was 7 inches long. The arms were 24 inches long, at an angle of approximately 48 degrees to each other. The goal boxes were 6 inches wide, 12 inches long, and 6 inches high, and were placed at right angles to each arm a few inches from the end. A door made of 1/4-inch screen was located at the start box exit, and two doors of clear polyethylene at the entrances to the goal boxes. All doors could be raised and lowered by *E*.

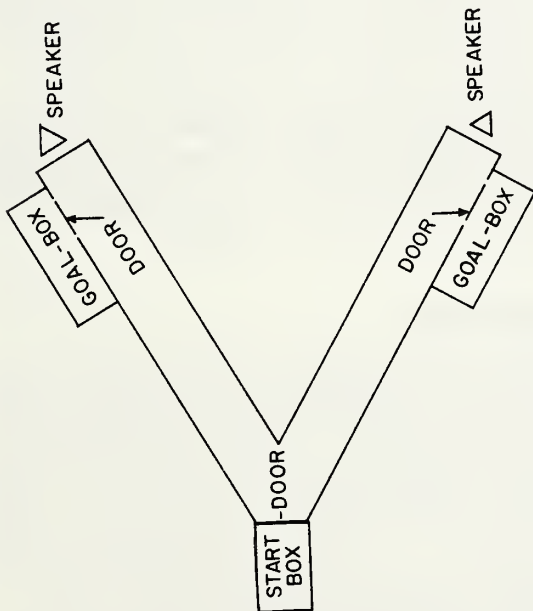


Figure 5. Y-maze Employed in Auditory Localization Task (Experiment I)

A pulsed white noise produced by a single random noise generator (Scott, Model 811-B) was played through a 4-inch speaker (Marsland, Model LS412-3) located at the end of each arm, at an intensity of 54 dB as measured at the start box. The noise interval, consisting of a 0.5-second pulse followed by a 0.1-second break, was controlled by two Hunter Interval Timers (Model 111-B). The timers were placed outside the test room to eliminate relay noise which might distract from the spatial aspect of the CS.

### Procedure

At 100 days of age, *Ss* were placed in the maze (adaptation) for 15 minutes of free exploration per day for four consecutive days. During this time, no noise was generated by the apparatus.

*Ss* were subsequently trained to choose the arm *not* emitting noise. A shock of 0.25 mA was administered whenever *S* entered the wrong arm, and continued until the animal returned to the choice point and then entered the silent arm (correction method). A Gellerman series of reinforcements was used (Hilgard, 1951), each animal receiving 10 trials per day for a maximum of 300 trials. Learning criterion consisted of not more than one error per day for two consecutive days.

Some *Ss* displayed a tendency to form directional preferences and subsequent position habits. Such habits were broken by continuous reinforcement to the non-preferred side until three consecutive correct runs were elicited. However, since no group showed a greater tendency to form position preferences than the others, and since the trials required to break the habits did not alter the final relative group data, these trials were not included in the final scores.

Trials were presented approximately every 90 seconds, with an inter-trial interval of at least 60 seconds. Before the start box gate was lifted, the pulsed noise was presented for 15 seconds; *S* was shocked in the start box if running was not initiated within 15 seconds after the gate had been lifted. The CS was terminated as the animal entered the goal box. This

procedure allowed *S* 10 to 15 seconds in the goal box after each run.

At the end of each test session, *Ss* were given individual access to food and water for one hour. They were then returned to their respective home cages, where they had access only to water until the following day.

Since each of the two litters was tested separately, at about one month apart, the present experiment may be considered to entail an independent replication.

## Results

Overall differences between the three groups were significant with respect to both trials-to-criterion scores ( $p < 0.02$ ) and to error scores ( $p < 0.02$ ), as measured by the Kruskal-Wallis non-parametric analysis of variance (Siegel, 1956). Since a number of scores exceeded the arbitrary limit of 300 trials by an indeterminate amount, Mann-Whitney *U*-tests (Siegel, 1956) were employed for all subsequent comparisons.

Table 4 illustrates the range and medians of trials-to-criterion and error scores for the three groups. The age at onset of blindness was clearly an important factor in the observed differences between the groups. The late-blind *Ss* were significantly superior to the early-blind, both in their trials-to-criterion scores ( $p < 0.02$ ) and their error scores ( $p < 0.02$ ).

TABLE 4

Comparison of Ranges and Median Scores of Early-Blind, Late-Blind, and Sighted Subjects, Y-maze Apparatus (Experiment I)

| Group       | N  | Trials-to-Criterion |     | Errors |     |
|-------------|----|---------------------|-----|--------|-----|
|             |    | Range               | Mdn | Range  | Mdn |
| Early-blind | 12 | 60-300              | 150 | 17-101 | 38  |
| Late-blind  | 10 | 20-130              | 80  | 9- 36  | 28  |
| Sighted     | 5  | 70-150              | 95  | 19- 55 | 30  |

The outcome of the sighted group, however, was not as clearcut. These *Ss* performed at a level intermediate between that of early- and late-blind *Ss*, but did not differ significantly from either. Nevertheless, inspection of the table reveals their scores more clearly resemble those of the late-blind *Ss*.

## EXPERIMENT II, FACTORS IN EARLY-LATE DIFFERENCES

A second study was conducted to examine possible factors that may have produced the early-late differences observed in Experiment I. Axelrod (1959) has suggested that early-blind *Ss* might suffer a general learning impairment; if so, then it might be expected that they would perform relatively as poorly on a non-spatial task as on a spatial one. Thus, the second experiment required *Ss* to learn a non-spatial auditory discrimination.

## Subjects

Twenty albino rats, comprising two litters, were randomly divided into two groups at 10 days of age. Using the procedure outlined in Experiment I, all pups were individually anesthetized, and seven were blinded by enucleation. At approximately 90 days, all animals were again anesthetized, and six were blinded; seven *Ss* remained sighted. They were then returned to individual laboratory cages, and allowed food and water *ad libitum*. Experimenter bias was controlled by those methods used in the first study.

## Apparatus

The auditory discrimination apparatus consisted of a wooden alley, 48 inches long, 8 inches wide, and 8 inches deep. This was divided into three segments: a start box, 1 foot in length; the alley itself, 2 feet in length; and a goal box, 1 foot in length. A vertically-sliding wooden door separated the start box from the alley, and a one-way panel, which *S* could open by pushing with its nose, provided the entrance to the goal box.

A 4-inch speaker (Marsland, Model LS412-3) was located in the center of the back wall of the start box. Either of two tones, 200c/s and 2000 c/s at 80 dB as measured at the start box, could thus be delivered from the same source, and were produced by a Hewlett-Packard audio oscillator (Model 201C).

#### Procedure

On the eleventh day following the second operation, adaptation to the discrimination apparatus was begun. After three days of adaptation, in which each *S* was allowed to explore the start box, alley, and goal box for 15 minutes, training was begun. This "go/no-go" task required the *S* to remain in the start box whenever the 200c/s tone was sounded, and to run down the alley and open the door of the goal box when the 2000 c/s tone was presented. The CS was presented for 10 seconds before the start box door was opened, and was terminated as soon as *S* entered the goal box. If the animal ran when the 200 c/s tone was on, a 0.25 mA shock was administered in the alley, the goal box was barred, and *S* was forced to return to the "safety" of the start box. Similarly, if *S* remained in the start box for longer than 15 seconds after the door had opened when the 2000 c/s tone was on, a shock was presented until running was initiated.

Ten trials per day were given, again using the Gellerman series, and learning criterion consisted of not more than one error per day for two consecutive days.

#### Results

Overall differences between the three groups in the "go/no-go" situation only approached significance with respect to trials-to-criterion scores ( $0.3 > p > 0.2$ ) and error scores ( $0.1 > p > 0.05$ ), as determined by a Kruskal-Wallis non-parametric analysis of variance.

Table 5 illustrates the medians and ranges of trials-to-criterion and error scores for the three groups. Surprisingly, the early-blind *Ss* were superior to the late-blind, both in trials-to-criterion ( $p = 0.038$ ) and error scores ( $p = 0.011$ ).

TABLE 5

Comparison of Ranges and Median Scores of Early-Blind, Late-Blind, and Sighted Subjects, "Go/No-Go" Auditory Discrimination (Experiment II)

| Group       | N | Trials-to-Criterion |     | Errors  |       |
|-------------|---|---------------------|-----|---------|-------|
|             |   | Range               | Mdn | Range   | Mdn   |
| Early-blind | 7 | 180-530             | 310 | 77-223  | 139   |
| Late-blind  | 6 | 400-530             | 515 | 146-259 | 224.5 |
| Sighted     | 7 | 270-530             | 400 | 125-265 | 166   |

Once more, the outcome of the sighted group was not clearly defined. As in Experiment I, they performed at a level intermediate between the early-blind and late-blind *Ss*, without differing significantly from either.

#### EXPERIMENT III, EMOTIONAL REACTIVITY

A third experiment was carried out to ascertain whether the observed differences in performance between early-blind, late-blind, and sighted animals could be attributed to possible differences in emotional reactivity, a factor known to affect performance in other avoidance learning situations. Levine (1956), for example, has found that rats, subjected to traumatic shock prior to weaning, show a lower level of emotionality as adults than their non-shocked littermates, and learn shock avoidance behavior significantly faster. From such reasoning, then, it might be argued that the trauma of early enucleation in the present investigation could cause the early-blind animals to differ from their littermates on such an emotionality dimension, resulting in the observed learning differences.

#### Subjects

Twenty-six albino rats, comprising two litters, were employed.

Following the procedure outlined in the previous experiments, all pups were individually anesthetized with ether at 10 days of age, and 11 randomly chosen *Ss* were peripherally blinded by enucleation. The pups were then returned to their respective nests; after weaning at 21 days, males and females were separated and placed in colony cages. Once more, at 90 days all animals were anesthetized, and seven of the remaining 15 were blinded. All were returned to individual cages, and allowed food and water *ad libitum*.

### Apparatus

The apparatus consisted of an open-field box, long considered a reliable device for the measurement of emotionality in animals (Denenberg, 1962). The field was a large wooden box, 60 inches long, 24 inches wide, and 18 inches deep. Parallel lines had been drawn across the width of the floor, spaced 6 inches apart.

### Procedure

On the eleventh day following late-blinding, each *S* was individually placed in the center of the open-field in randomized order. The number of lines crossed during a 5-minute period was recorded, while *E* sat quietly at a distance of 6 feet from the apparatus.

### Results

The ranges and medians of the emotionality scores (i.e., the number of lines crossed in the 5-minute test interval) are shown in Table 6.

The number of lines crossed by the early-blind (*Mdn* = 60.6), late-blind (*Mdn* = 71.5), and sighted animals (*Mdn* = 59.9) did not differ significantly from one another.

Clearly, then, the differences previously observed between the three groups in auditory avoidance learning are not interpretable in terms of emotional reactivity; the age at onset of blindness simply does not appear to be a factor affecting later emotionality in animals.

TABLE 6

Comparison of Ranges and Median Scores of Early-Blind, Late-Blind, and Sighted Subjects, Open-field Test (Experiment III)

| Group       | N  | Range  | Mdn  |
|-------------|----|--------|------|
| Early-blind | 11 | 35-90  | 60.6 |
| Late-blind  | 8  | 44-114 | 71.5 |
| Sighted     | 7  | 14-96  | 59.9 |

### EXPERIMENT IV, ROLE OF LENGTH OF BLINDNESS

A major question yet to be dealt with by this investigation concerns the possible role of *length of blindness*. By implication, the differences between early- and late-blind animals observed in the first two experiments have been attributed to the age at onset of blindness. At the time of testing, however, the early-blind *Ss* had been sightless for 100 days, while the late-blind animals had been deprived of vision for only 10 days.

The primary contention of this investigation is that vision early in the life of an organism plays a crucial role in the development of some mechanism of perceptual integration responsible for effective spatial behavior. It is the lack of such a mechanism in the early-blind animals, presumably, that underlies their subsequent poor ability in an auditory-spatial situation. Conceivably, however, *non-spatial* auditory function may not require such integration for its development; rather, this ability may very well be enhanced by prolonged forced attention to environmental auditory cues, and thus result in the relatively superior performance by early-blind animals under certain conditions (e.g., the non-spatial condition of Experiment II). The possibility remains, therefore, that auditory-spatial abilities are in some way affected by duration of visual deprivation. In order to control for such a possibility, then, a further study was conducted in which age at onset and duration of blindness were manipulated independently.

## Subjects

Sixty-four albino rats, comprising nine litters, were used. These animals, assigned randomly to one of nine groups, provided various combinations of four ages at onset of blindness and four durations of blindness. Three early-blind and six late-blind groups were thus prepared in the following manner:

At 10 days of age, all pups were anesthetized, and 24 were selected at random for blinding by enucleation. Following the operation, each pup was returned to its mother, and left until weaning at 21 days of age.

At approximately 50 days of age, all *SS* were again individually anesthetized, and 21 of the remaining sighted animals were blinded. At this point, nine of the early blind (0-60 group) and eight of those just blinded (50-60 group) were placed in individual cages; all others were returned to their respective colonies.

Approximately 50 days later, 14 of the remaining 19 sighted animals were blinded by enucleation (all untested *SS* were anesthetized). The following *SS*, comprising three groups, were then placed in individual cages:

- a. ten of the remaining 16 early-blind *SS* (0-110 group)
- b. eight of the *SS* blinded at 50 days of age (50-110 group)
- c. seven *SS* blinded at 100 days of age (100-110 group)

The remaining 23 animals were replaced in colony cages.

The third and final phase of the procedure began at 150 days of age, when each remaining untested *S* was placed in an individual cage. Thus, four final groups were prepared:

- a. the six remaining early-blind *SS* (0-160 group)
- b. the five remaining *SS* blinded at 50 days (50-160 group)
- c. seven of the animals blinded at 100 days (100-160 group)
- d. five *SS* blinded at 150 days (150-160 group).

The animals were then allowed food and water *ad libitum* for 10 days until testing began.

## Apparatus

The apparatus consisted of the Y-maze described and employed in Experiment I (Fig. 5).

## Procedure

The procedure was not essentially different from that described in Experiment I. On the 11th postoperative day, adaptation to the test apparatus was begun (i.e., at 60 days of age for the 0-60 and 50-60 groups; at 110 days of age for the 0-110, 50-110, and 100-110 groups; and at 160 days of age for the 0-160, 50-160, 100-160, and 150-160 groups).

Once again, learning criterion consisted of not more than one error per day for two consecutive days.

## Results

Since 30 of the 64 animals failed to reach learning criterion within the 300-trial limit, the Kruskal-Wallis non-parametric analysis of variance and the Fisher Exact Probabilities Test (Siegel, 1956) were used in the analyses of the data.

Analysis of variance revealed significant overall differences in trials-to-criterion and error scores between the nine groups studied ( $p < 0.05$ , for both measures). Table 7 illustrates the medians and ranges, as well as the number per group reaching criterion within the established limit of 300 trials. Randomization tests (Siegel, 1956) also revealed certain clear-cut differences between groups. The three groups of *SS* blinded at 10 days of age did not differ significantly from one another, nor did the six groups blinded later in life, *regardless of the duration of their blindness*. Moreover, no sex differences between or within groups were discernible.

The three early-blind groups, however, did require a significantly greater number of trials to reach criterion than did their late-blind littermates ( $p < 0.0001$ ), thus serving

TABLE 7

Comparison of Ranges and Median Scores, and Percentage of Subjects in Each Group Reaching Criterion, Y-maze (Experiment IV)

| Group     | N  | Trials-to-Criterion |     | Errors  |       | Number Reaching Criterion | Percentage |
|-----------|----|---------------------|-----|---------|-------|---------------------------|------------|
|           |    | Range               | Mdn | Range   | Mdn   |                           |            |
| 0 - 60    | 9  | 140-300             | 300 | 52-151  | 108   | 3                         | 33.3       |
| 0 - 110   | 10 | 130-300             | 300 | 39-154  | 126   | 2                         | 20.0       |
| 0 - 160   | 5  | 280-300             | 300 | 115-158 | 139.5 | 1                         | 20.0       |
|           |    |                     |     |         |       | Mean =                    | 24.4       |
| 50 - 60   | 8  | 40-300              | 135 | 12-156  | 55.5  | 6                         | 75.0       |
| 50 - 110  | 8  | 80-300              | 300 | 29-163  | 120.5 | 3                         | 37.5       |
| 50 - 160  | 5  | 30-260              | 190 | 12-121  | 63    | 5                         | 100.0      |
| 100 - 110 | 7  | 20-300              | 230 | 7-163   | 84    | 5                         | 71.4       |
| 100 - 160 | 7  | 20-300              | 140 | 7-126   | 59    | 6                         | 85.7       |
| 150 - 160 | 5  | 50-300              | 140 | 20-140  | 63    | 3                         | 60.0       |
|           |    |                     |     |         |       | Mean =                    | 71.6       |

to replicate the results observed in Experiment I. There were two exceptions:

1. the 50-110 group failed to differ from both the 50-60 and 100-160 groups ( $p < 0.10$ ),
2. the 0-60 group did not differ from the 50-110, 100-110, or 150-160 groups.

On the whole, though, it is clearly evident that early-blind animals perform more poorly than those blinded later in life.

The differences between early-blind and late-blind animals may be more fully appreciated by grouping *all* subjects in terms of either age at onset or duration of blindness. Figure 6 illustrates the percent to reach criterion as a function of age at onset of blindness. Clearly, those Ss blind from birth are inferior to those animals which had had at least some visual experience. It is also apparent, on the other hand,

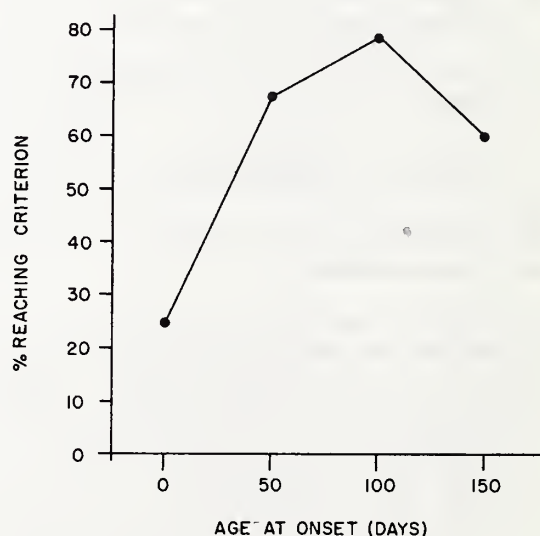


Figure 6. Percent of Subjects Reaching Criterion, Y-maze Task, as a Function of Age at Onset of Blindness (Experiment IV)

that prolonged experience with blindness neither impairs nor facilitates the performance of either major group on this task. Figure 7, while demonstrating once again a late-blind superiority, also shows a marked lack of effect as a function of the duration of visual loss; non-parametric trend analysis (Ferguson, 1965), carried out on the ranked trials-to-criterion scores of the two groups, failed to reveal a significant trend for either the early-blind or late-blind groups.

## DISCUSSION

Before continuing with the last, human experiment, a brief discussion of the data obtained so far is in order. The primary aim of the present investigation has been to examine the effects of age at onset and duration of blindness on rats' performance in an auditory-spatial learning situation. To this point, the results offer cogent evidence that the age at onset of blindness represents a far more important variable in determining adult performance in auditory localization than does the duration of visual loss. The fourth reported investigation not only replicates the results of Experiment I, but also extends them by demonstrating the relative unimportance of length of blindness.

The results of the sighted animals have constantly provided a dilemma; rephrased, the basic thesis of this paper is that efficacious localization ought to correlate directly with the amount of visual experience within an animal. Yet it is evident that on the spatial task, the sighted animals consistently performed about as poorly as their early-blind littermates. Such a finding would appear to present a logical problem: if the performance of the sighted group was indeed "normal," then late-blindness produces "better-than normal" spatial learning ability. By this argument, then, the effects of early blindness do not consist of an *impairment* in spatial learning ability, but rather, in an *inability to improve* following the loss of vision. Thus, the results still demonstrate an early-blind deficit, in the sense that their blindness has failed

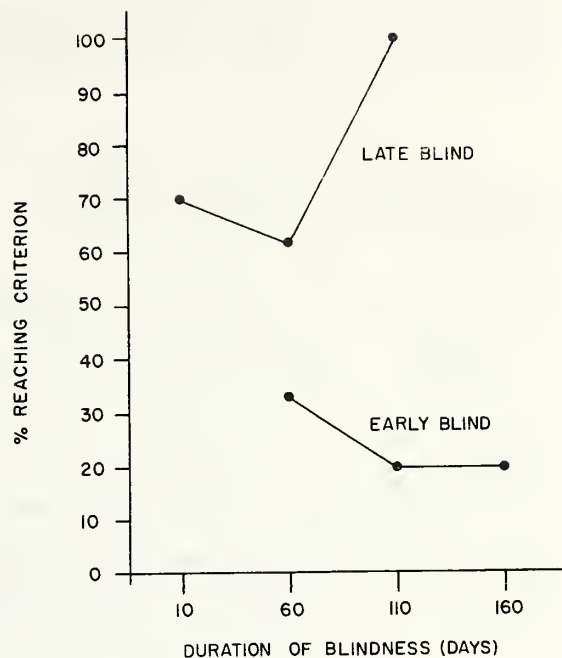


Figure 7. Percent of Subjects Reaching Criterion, Y-maze Task as a Function of Duration of Blindness (Experiment IV)

to result in enhancement. Such a facilitatory effect would appear to require an enforced attention to auditory cues in the environment because of the visual loss, as well as prior visual experience. Although sighted animals have had at least as much visual experience as their late-blind littermates, they remain visually-dominated nonetheless, and likely enter the experimental situation with visual "hypotheses" (Krechewsky, 1932). With such a premise, then, it is not surprising that their Y-maze performance is hampered by an initial failure to attend to (relevant) auditory cues when first confronted with a learning situation.

## EXPERIMENT V, AGE AND BLINDNESS

The final phase of the present investigation sought to examine the effects of the age at onset of blindness in humans, and particularly on auditory-spatial functioning. It is evident from the preceding experiments that this variable represents a factor of considerable importance, at least

in rats, for the development of spatial ability in the blind. Curiously, however, it is a factor that has not been studied in humans as systematically as might be desired.

A number of investigators, reporting in the 1920's and 1930's, examined blind-sighted differences in auditory localization (e.g., Caldwell, 1929; Foster, 1934; George, 1934; Hayes, 1935; Seashore and Ling, 1918). Because of numerous weaknesses in sampling and testing procedures, however, the results have been equivocal. Often, the investigators have failed to specify the ages of their subjects, etiology and ages at onset, and/or degree of blindness. Similarly, testing procedures have frequently lacked the rigor and sensitivity necessary for producing less than ambiguous results. Consequently, the findings and conclusions have been inconsistent. About half have reported the blind to be superior to the sighted, while the rest have reported no differences between the blind and sighted in localization accuracy. None, incidentally, has ever reported a sighted superiority on such a task.

The purpose of this, the final experiment, then, was twofold: first, it was obvious that a precise and reliable method of measuring auditory localization in the blind was needed in order to determine whether, as Axelrod (1959) has suggested, "There is reason to believe. . . that in the probably much-practiced task of sound localization, the blind are somewhat better than the sighted" (p. 11). More importantly, this investigator felt that age at onset of blindness, a factor ignored without exception by earlier studies of auditory localization in the blind, merited close consideration, in view of results thus far.

### Subjects

Blind Ss were comprised of 36 students from the Ontario School for the Blind in Brantford, Ontario. The groups consisted of 18 congenitally blind and 18 adventitiously blind (nine of each sex in both conditions), who met all of the following criteria:

1. I.Q. within the normal range of the general seeing population,

as measured by the *Interim Hayes-Binet Test for the Blind* (Hayes, 1942).<sup>3</sup>

2. Absence of evidence of brain damage.
3. Absence of hearing abnormalities.
4. Total (as opposed to legal) blindness.<sup>4</sup>

Without exception, the cause of blindness in all early-blind Ss was retrolental fibroplasia, an abnormal plastic overgrowth of capillaries in the choroid layer of the eye spreading over the retinal surface, and resulting in total blindness (Ashton, et al., 1953).

Of the late-blind subjects, six had been accidentally blinded (trauma); the remaining 12 cases resulted from retinoblastoma, a form of retinal cancer usually requiring bilateral enucleation (Adler, 1962).

Nine male and nine female control Ss were obtained from the Waterloo County School Division, Waterloo, Ontario. An attempt was made to match sighted to blind students as closely as possible in terms of age and sex. Further, in requesting the students, school authorities were asked that each S's I.Q. fall within the normal range of the seeing population. Table 8 indicates the degree to which matching attempts were successful. Although the groups did not

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<sup>3</sup>The *Interim Hayes-Binet Test for the Blind* is an individually administered test, taken, for the most part, from the L and M forms of the 1937 Stanford-Binet Scales. Hayes (1950) claims the test yields a normal distribution of scores, with a blind population mean of 100, standard deviation of 15.

<sup>4</sup>Information regarding neurological, auditory, and visual conditions was gleaned from medical protocols of students' semiannual ophthalmological examinations.

TABLE 8

Mean Age, I.Q., and Vocabulary (Raw and Scaled) Scores for Early-Blind, Late-Blind, and Sighted Subjects  
(Experiment V)

| <u>Group</u> | <u>N</u> | <u>Age<br/>(yrs.)</u> | <u>I.Q.</u> | <u>Vocabulary<br/>(raw score)</u> | <u>Vocabulary<br/>(scaled score)</u> |
|--------------|----------|-----------------------|-------------|-----------------------------------|--------------------------------------|
| Early-blind  | 18       | 13.6                  | 100.4       | 39.4                              | 9.17                                 |
| Late-blind   | 18       | 15.2                  | 119.4       | 42.0                              | 10.56                                |
| Sighted      | 18       | 13.9                  | 112.3       | 48.9                              | 12.67                                |

differ significantly from one another in chronological age, the mean I.Q. scores of the late-blind and sighted *SS* were significantly higher than those of the early-blind ( $p < 0.01$ , for both comparisons). W.I.S.C. Vocabulary scores, known to correlate highly with overall I.Q. (Wechsler, 1958), and which represent the only quantitative intellectual measure common to *all SS* in this investigation, also showed group differences. Notably, however, no differences between early-blind ( $\bar{X} = 39.4$ ) and late-blind ( $\bar{X} = 42.0$ ) could be discerned ( $p > 0.2$ ); both groups, however, were significantly lower than the sighted *SS* ( $\bar{X} = 48.9$ ;  $p < 0.01$  and  $p < 0.05$ , respectively).

#### Apparatus

Figure 8 illustrates the auditory localization apparatus used in this experiment. The tubular metal booms, supported by a rigid frame of the same material, projected 3.75 feet from a circular disc centered directly above the *S*'s head. A vertically-adjustable 4-inch speaker (Marsland, Model LS412-3) was affixed to a metal rod extending down from the end of each boom; only one of the speakers was actually ever operated. Figure 8 shows that an experimenter could stand behind the subject and be able to rotate the boom up to 360° about the *S*'s head at ear level, and to place the operational speaker precisely at a predetermined locus at one of 12 positions by means of an indicator needle suspended from the frame.

Along the perimeter of the disc were numbers 1 to 12, spaced 30° apart, coinciding with 12 speaker positions around the subject's chair. A 1-second 50 dB pure tone could thus be presented by the experimenter from any one of 12 possible positions.

Tones were generated by a Hewlett-Packard Audio Oscillator (Model 210C), and their durations were controlled by a Hunter Interval Timer (Model 111-B). Each tone consisted of one of three frequencies, 100 c/s, 1,000 c/s, or 10,000 c/s, and were matched for intensity at the center of the subject's chair.

The subject indicated his response by pressing one of 12 buttons arranged at 1-inch intervals about a 5-inch diameter plastic "clock," held on his lap during testing. One button, considerably larger than the rest, was located at the top of the clock face, and represented 12 o'clock, serving to provide the subject with a means of orienting to the remaining eleven buttons. Pressing a button activated one of 12 small lights on a panel behind the testing apparatus, and indicated the response to the experimenter. All the blind subjects wore braille wristwatches; they were thus quite familiar with determining time tactually, and were well aware of the similarity between their own watches and the response apparatus. It was felt that this approach was more "fair" for the blind child than the more traditional "pointing" procedure.

Subjects were tested in a room (13' x 8' x 7') in a mobile laboratory. This modified house trailer

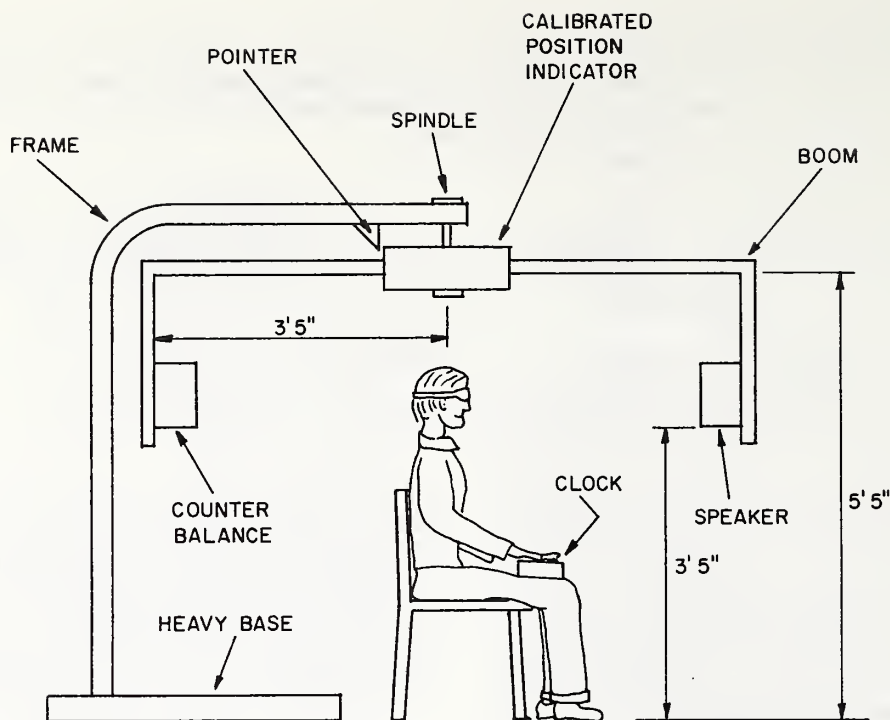


Figure 8. Auditory Localization Apparatus (Experiment V)

could be moved from one school to another, and served as a standard laboratory for testing all subjects.

#### Procedure

All subjects were individually tested on two separate occasions, lasting from 40 to 80 minutes each, depending upon the performance of the student. All subjects wore yellow translucent goggles throughout both sessions. Since all blind students were at the same school, both groups were tested concurrently, and subjects were met in a random order. The sighted controls, however, were tested a number of months later, since the mobile laboratory had to be transported by truck from school to school.

The first test session, which took place in a quiet room in the school, consisted of an initial interview and, among a number of tasks (not reported in this paper), the administration of the Vocabulary Subtest of the Wechsler Intelligence Scales for Children (W.I.S.C.) (Wechsler, 1962). The subjects were sent to the mobile laboratory by their home

room teachers for the second meeting, where they were tested on the auditory localization task. Subjects were told simply, "We are interested in learning how well students do on certain kinds of hearing tasks." They were assured that what they were doing had no relation to their school work, and that their participation was entirely optional. No one, however, refused to participate; indeed, all subjects appeared keenly interested and most eager to begin.

The auditory localization task was divided into two phases. The first phase required the subject to localize the source of the tone with the head in a free position. In the second phase, the subject's head was held steady by means of a bite-bar, so that cues normally provided by head movements (Wallach, 1939) were drastically reduced.

Subjects were seated as comfortably as possible in a contoured wooden chair, and were presented, at intervals of approximately 30 seconds, with twenty-four 100 c/s tones at predetermined (random) positions about their heads; thus, two such tones were

presented from each of the twelve possible positions. These were followed by twenty-four 1,000 c/s tones, also randomly distributed over the twelve "clock" positions. Finally, twenty-four 10,000 c/s tones were presented in a similar manner. After 72 presentations over the three frequencies, the entire procedure was repeated with the head held steady.

## Results

As a result of the observed differences in I.Q. between the three groups, the auditory localization scores were analyzed by means of covariance analysis (Winer, 1962). In this treatment of the data, W.I.S.C. Vocabulary raw scores were used as the covariate, since they comprised the only measure of intelligence applied to all three groups. The analysis revealed the overall differences in localization accuracy, with intellectual ability held constant, to be highly significant ( $F = 10.07$ ,  $p < 0.01$ ). Moreover, correlations between vocabulary and localization scores, both for overall and within-group comparisons, were not significant. Table 9 illustrates the mean number of correct localizations under the "head free" and "head restrained" conditions. Late-blind *Ss* were significantly more accurate than either the early-blind ( $p < 0.002$ ) or the sighted ( $p < 0.002$ ) under both conditions combined, while the early-blind and sighted subjects did not differ significantly from one another. The similarity of these results to those of rats in Experiment I is certainly worth noting.

Restricting head movements in the second phase of the procedure produced a predictable and significant impairment in performance ( $p < 0.002$ ). No one group, however, was more or less affected by the restriction than any other. Figure 9 illustrates the relationship.

Accuracy of localization also varied with frequency. As shown by Figure 10, accuracy decreased inversely with frequency, but overall differences between groups in the degree to which frequency affected performance were not significant. Finally, no differences could be seen between groups in the number of reversal errors (e.g., front-back, 1-5 o'clock, 11-7 o'clock, etc.).

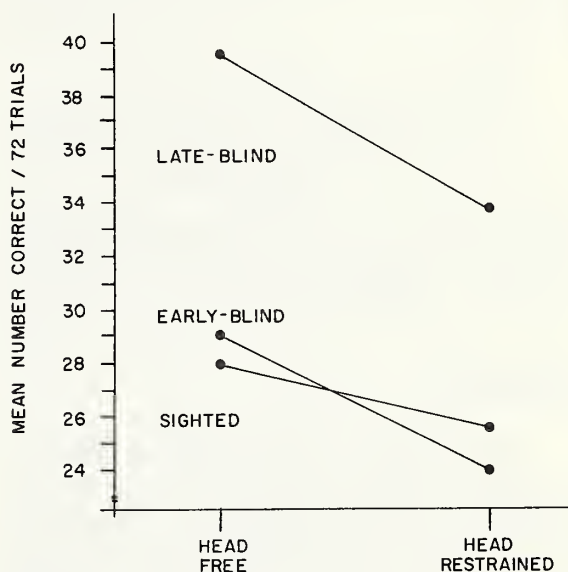


Figure 9. Accuracy of Localization by Group, Head Free *vs.* Head Restrained (Experiment V)

TABLE 9

Mean Number of Correct Localizations Per 72 Trials with Head Free and Restrained (Experiment V)

| Group       | Head Free     | Head Restrained | Total         |
|-------------|---------------|-----------------|---------------|
| Early-blind | 29.17 (40.5%) | 24.06 (33.4%)   | 53.22 (36.9%) |
| Late-blind  | 39.56 (54.9%) | 33.78 (46.9%)   | 73.33 (50.8%) |
| Sighted     | 28.06 (39.0%) | 25.56 (35.5%)   | 53.61 (37.2%) |

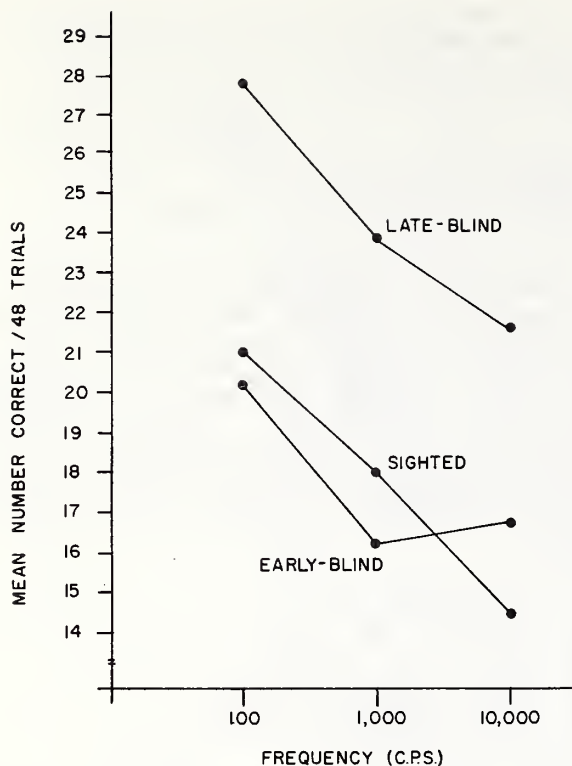


Figure 10. Accuracy of Localization by Groups as a Function of Frequency (Experiment V)

## DISCUSSION

To a much greater extent than the rat's, man's vision is probably his most sophisticated and informative sense, and therefore the range and variety of experiences are necessarily restricted for the blind child. Conceptualization of unreachables (clouds, skyscrapers, and spiders' webs, to name a few) is impossible; if understanding of these comes at all, it is only through long and arduous exploration, and at that, likely inadequate. Many even suggest that the blind child may even experience difficulty in attaining a proper concept of his own physical self (McKinney, 1964; Poeck and Orgass, 1964). Similarly, Gesell and Amatruda (1964) have hinted at the relation that surely exists between self-concept and a spatial sense, and have insightfully suggested that

(The blind infant's) . . . "physical self is ambiguously involved with garments and with blankets and with furniture. He has not the assistance of sight to make the

fundamental distinction between his anatomical self and all these appurtenances. . . for the same reason he must have profound difficulties in building up images appropriate to the voices which he hears. . . . He lives in a world of voices, but the voices come out of nothingness and then go back into nothingness," (p. 259).

Clearly, the most relevant consideration for the present investigation concerns the development of a "spatial sense" by a blind infant. Developmentally, no single sense can be viewed in isolation; rather, as Gibson (1966) has proposed, the behavioral development of an infant must be looked upon as comprised of a number of perceptual "systems," which are classified by "modes of activity" rather than by the more traditional "modes of conscious quality" (p. 49). The development of perceptual behavior, in other words, does not depend upon any one sense, but is the product of a co-operative interaction between many.

From the very beginning of a normal infant's life, there are important motor and other components involved in all of his perceptual behavior. His development of a spatially integrated world comes from active participation in it and manipulation of it; this holds not only for the human (Rock, 1966), but for lower species as well (Held and Hein, 1963).

The importance of normal early sensorimotor stimulation for the adaptive development of organisms is also one of the central themes of Hebb's (1949) theorizing. The theory emphasizes not sensory stimulation *per se*, but an interaction of sensory *with* motor experience, for subsequent effective organization of behavior. In those subjects blind from birth, or from the first few months of life, the visual engrams, considered as the stock of visual images somehow acquired in the process of experience, are either absent or lost through disuse. Development, therefore, consists of the gradual establishment of such visual schemas, and learning to correlate them with tactile-kinesthetic experience. Thus, to patients who have recently recovered vision after lifelong blindness (von Senden, 1932), visual stimulation is at first meaningless. The earlier the onset of the blindness, the faster the dissipation of such schemas (Blank, 1958), and, by the same token, the slower is the patient in learning visually-guided behavior (Valvo, 1968).

Carr (1935) also recognized the importance of sensory interaction in his thoughts on the development of a sense of space; even more germane to this investigation, however, is his discussion of how the individual develops perception of auditory space:

"Auditory, somesthetic, and visual sense objects *per se* have no spatial relation to each other. They become spatially defined in reference to each other in virtue

of their association with movements adapted to their manipulation. Two diverse sensory objects that are associated with a common manipulative response are regarded as having the same location. . . ." (p. 31).

It is a reasonable assumption, then, that a congenitally-blind individual, who has not had full opportunity to determine visual, auditory, and kinesthetic relations experientially would suffer great difficulty in localizing sound sources. Auditory space *per se*, of course, does not exist (Rock, 1966); an auditory space is developed only by learning cross-modal interrelations. This investigation, and most particularly Experiment V, has clearly supported such a notion.

Further research, moreover, might determine more precisely the extent of cross-modal interaction by separately manipulating auditory and motor (stimulus and response?) aspects of localization tasks independently. In this investigation, for instance, rats were required to learn a Y-maze auditory localization task involving a spatial response (right or left turn) to a spatial discriminandum (right or left noise source); in the frequency discrimination task (Experiment II), on the other hand, both response and discriminandum were non-spatial in nature. Ideally, then, the development of some task separating the two components involving, say, a Y-maze (spatial) response to a frequency (non-spatial) stimulus might help clarify the relative importance of the spatial aspects inherent in the organism's perception of space. Ongoing research in this laboratory is now also attempting to unravel the underlying mechanisms of temporal-spatial (i.e., sequential organization of behavior) interaction, and the failure of the early-blind to cope not only with space, but with time as well.

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# A COMPARATIVE STUDY OF THE EFFECTS OF EARLY BLINDNESS ON THE DEVELOPMENT OF AUDITORY-SPATIAL LEARNING

Informal Presentation: Manly Spigelman

## VISION AND COGNITIVE DEVELOPMENT

One thing I should like to make clear is that I am not an expert on blindness. I am interested primarily in sensory perceptual cognitive development; the role played by the various senses. One way to study the role played by vision in cognitive development is to see what happens to an organism that does not have it. There is a somewhat different emphasis, and the distinction is rather a crucial one for subsequent discussion.

## ANIMAL STUDIES

As a graduate student in physiological psychology, I became very interested in the work of Lashley, who, about 35 years ago, had been examining the role of the "visual" cortex in nonvisual functions in learning. I was working on ablations of the striate and prestriate cortex in rats, producing cortical blindness. As a control group and only as a control I felt we should have some subjects who were peripherally blind so as to know whether their learning deficit was due to a central factor or a lack of vision per se. I became more interested in my control group than I was in the experimental group. These peripherally-blind animals fascinated me. They were late blind, blinded at maturity at this point, which for a rat is about 90 days of age.

### Advantage of Using Rats

Perhaps I should say a few words here on the relevance and advantages of working with rats. An early-blind rat and an early-blind child behave

very similarly on certain kinds of perceptual learning tasks. The results are striking at times. The advantage of using rats, of course, is the degree of control that you have over your subjects. Also there is a matter of time. For instance, we have just begun a rather lengthy project that will take about two years. We are trying to study the interaction of age at enucleation and length of blindness with retrograde degeneration in the brain. The optic nerve degenerates if you remove an eyeball, and the question is at what point the degeneration progresses to a higher level, the lateral genicular nucleus, and then on to the cortex itself. Is the progression of degeneration any faster if the animal is blinded at 50 days of age, as opposed to 100 days of age, or as opposed to 200 days of age? It will take some time to answer these questions.

### D. O. Hebb's Work

At about this time I became interested in the work of D. O. Hebb at Yale University. Hebb had some extraordinary insights--in the late 1940's--many of which have subsequently borne fruit. He was concerned with the relation between neurological development, experience, and behavioral development, matters that are of concern to all of us.

He was very concerned with attempting to relate the experiential and behavioral aspects with some sort of neurological enrichment. We talk about early sensory enrichment, early perceptual enrichment. He was concerned with what the effects are in terms of brain enrichment. The recent work of people like Rosenzweig, and

Kretch, and Bennet and others, I think, have borne fruit, but at Hebb's time, it was rather speculative. He took a litter of rats and enucleated half of them at about 12 days of age. The eyes normally open at 14 days, approximately. The litter of rats, half of them blinded before the eyes normally open was put into individual laboratory cages, which is a nonstimulating environment, to put it mildly. The other half of the litter were blinded at maturity. Then at about 100 days of age--the same parameters, you will notice, that I have been using in most of my rat research--all of these animals were tested on an "animal test of intelligence," the Hebb-Williams Maze. It is basically an alternation maze. It requires the animal to go through successively more difficult discrimination problems, structured similarly to the Wechsler Scales. It gets progressively more difficult, and at some early point the dullards drop out.

#### Early Blindness and Intellectual Impairment

He found that the late blinded animals performed significantly better on this "test of intelligence" than those blinded early in life. He concluded that there seemed to be a general learning impairment, a general intellectual impairment due to early blindness. It was subsequently corroborated by others; Hymovitch, Forgas, to name two. Interestingly enough, most of them came from McGill University, where Hebb was chairman of the psychology department at the time. Many people then were agreeing that the early blind must have a general impairment in learning set or some sort of general sensory-perceptual learning deficit.

Intuitively, if we can trust this, it would seem that a maze learning task, which virtually everyone had used with animals at that point, is a highly spatial thing, left, right, left right, and so on. To solve any maze-type task, one would think an organism would have to have some kind of concept of distal versus proximate location of an object or stimulus. It would seem that an early-blind organism would have

difficulty in acquiring these concepts.

#### Spatial Sense Testing

So if the impairment is specific, one immediately suspects a spatial deficit. If there is a specific handicap, perhaps it is in the spatial sense. At this point, I was beginning, incredibly naively, to think that we could solve the problem once and for all. We would give early and late blind rats a spatial problem, and see whether or not there was an impairment, which we did. Figure 5 illustrates a standard, ordinary Y-maze built out of plywood. The task involved a sound coming down one of the arms. It was an identical pulsed noise coming from a speaker at the end of each arm. The animal simply had to run into the arm not containing noise. There are a few reasons why I did not use an approach test. First, it is impossible to train a rat to go to the sound when there is shock involved in an experiment. No matter what, the animal is going to believe that the shock and the sound have something to do with one another. A conditioned emotional response is the most difficult kind to extinguish. Also, if the sound is coming from there, and you have to go over here, this would imply automatically a simultaneous comparison of out-here-ness versus out-there-ness. It would imply some sort of a spatial schema, if we can use such a term with rats, and I do not see why not.

The result was that the early blind did very poorly. Those animals blinded before the eyes normally opened took a median of 150 trials to reach criterion. Those animals that were blinded at maturity (90 to 100 days of age) took almost half as many, 80 trials to reach criterion, an incredible difference. There was a problem, though, in this experiment the early blind required 150 trials, the late blind 80, but the sighted required 95 trials. Statistically they did not differ from either blind group.

This poses questions. If I say that visual experience makes a better localizer, who has had the most visual experience? It is the sighted animals; yet they did not do as well as

the late blind who had less visual experience but indeed have had some. I suspect that it is an attentional problem. The sighted rats are just not paying attention. They are coming into the learning situation with visual hypotheses--they are looking rather than listening, because they have always looked, so that advantage of early visual experience is probably being negated by the fact that it is a confusing situation. They are attending to the wrong kind of cues. More of that later.

### Learning Ability Testing

The next obvious experiment to do was to verify whether the early blind were not in fact just inferior learners, as Hebb and numerous others had implied. The task had been a spatial one, but it was still a learning task, and empirically a fairly difficult one. One hundred fifty trials means it was very hard. We had to devise something at least as difficult to learn, also auditory, but nonspatial, in order to make the data convincing. What we did was to use the standard auditory discrimination device called a go/no-go straight alley situation. That is, a narrow box, about three feet long and a speaker. The animal starts at one end. If there is a 2,000 cycle-per-second tone emanating from the speaker, he has to run very fast to get to the other end or he gets shocked. If, on the other hand, there is a 200 cycle-per-second tone, he must stay put. This is a difficult thing for rats to learn because it involves the inhibition of a response. He is a pretty up-tight animal at this point, and he has to inhibit what comes naturally: to run or to freeze, depending on how scared he is.

The results were gratifying, though extremely confusing. If you have read any of my other papers, you know that I am not one to support a sensory compensation notion, that somehow the other senses become more acute when vision is lost. There are certain cognitive superiorities that I believe an early-blind animal or human may have, but there are not, as far as I can see, sensory compensations. However, look at what happens. On this task we get the early blind learning in 310 trials. This was obviously an even more difficult task,

so if it is just a matter of stupidity, this is where the discrimination should be greatest. The early blind took 310 trials, the late blind, 515, significantly different and *reversed*. I do not know what to do about the sighted animals, they came in the middle.

I need advice, especially to explain the sighted animals. At a recent seminar on perceptual development everybody wanted to talk about the sighted rats, which seem to intrigue most people. At one point I thought if they are attending to the wrong cues, so that when you put the sighted animal into an auditory learning situation, he is not an auditory learner at first and is attending largely to non-auditory cues, then supposing I turn out the lights? I did so. I painted fluorescent paint on the tails of each animal, and followed a fluorescent tail through the maze under a very dim red light.

The results were something like 160 trials for the early blind and about 90 for the late blind, so that is a replication. It took 180 trials for the sighted. They did even worse with the lights out, which makes sense. I am one of those people who cannot really enjoy Beethoven with my eyes closed. They have to be open. No vision is more distracting than visual distraction at times.

It is always interesting when you can get opposite effects in the same kinds of samples. We have, in fact, a complete reversal in this case. The same kinds of samples on two different tasks show opposite relationships. This I think reinforces our picture of the process, whatever it is.

### CHILD STUDIES

Enough of rats. The next question is whether it is possible to observe similar effects in children? I was very fortunate in that 20 miles from the University of Waterloo, where I was working at the time, there was the Ontario School for the Blind in Brantford, with close to 600 students. I was able to select 18 "congenitally blind"--I call them "congenitally blind," but the point was very well taken earlier today, I agree that they are not--and 18 late blind, matched as well as was feasible.

## Sound Location Testing

I will not go into much detail at this time. The child sat in a chair and there was a speaker rotating above his head on a silent nylon switch. At any one of 12 positions above his head he heard a tone, of either 100, 1000, or 10,000 cycles-per-second. This was done under two conditions, head free and head restrained. (The subject bit on a bite bar to restrain head movements.) I was trying to see what difference there was between early blind and late blind on auditory localization; whether one group is perhaps using a different kind of a cue from the other. We know the importance of very slight head movements from Wallach's and Stevens' work in the 1930's. Head movements make a big difference. There was a possibility that the late blind were using head movements more.

Different frequencies were used again to look for cues to direction such as the use of a sound shadow or of head movements. If there is a difference between the groups, what cues are one group using as compared with the other?

The answer is that it does not matter whether the head is held or free. With the head held, performance dropped for both groups as well as for the controls. (There were actually three groups. I had sighted controls from the Waterloo public school system.) Both Wallach and Stevens found in the 1930's that restricting head movement impairs auditory localization. This was no surprise, but it impaired it equally for all three groups. However, late blind were significantly superior to early blind, as were the rats, and sighted children performed as did the early blind. The sighted blindfolded children behaved like sighted rats. How is this to be explained? We talked about attentional mechanisms, and attending to the wrong cues, and having visual hypotheses, but I blindfolded all my subjects, the blind as well, just to be safe and I made sure that they understood the instructions, that they were going to attend to a sound. Nevertheless they behaved like the rats which, I suggested earlier, were attending to stimuli other than sound.

This briefly summarizes the contents of the formal paper and adds slightly to it. One of our current research projects is that of attempting to trace retrograde degeneration through the visual system. I am working with a certain kind of staining that hopefully will show the degenerating cells instead of those already degenerated, and will yield a little more information than older techniques. In another direction, Hebb and others have suggested that when it comes to the perception of space (just as it is in physics), in psychology, space and time are inseparable. One cannot imagine, say, looking at a triangle without thinking of the sequential organization of behavior, to use the title of Hebb's book. Scanning a triangle, scanning anything in the environment requires a temporal organization, a sequential organization.

## Time Estimation

One of the things that we have looked at is time estimation. Early-blind youngsters are very poor time estimators. We use a magnitude production technique where the child has to reproduce a sound that he has already heard without counting, without tapping his feet or things like that. Again, with sighted and late blind there is no difference, but the early blind do very badly. I got this idea from a cryptic little note imbedded in an article by Philip Worchel in 1951 in the *American Journal of Psychology*. Incidental to his main research he had done a minor experiment in which he took early-blind, late-blind and sighted children by the hand, out in an open area, up two sides of an imaginary triangle. He led them 50 feet in one direction and 60 feet in another. Then he left them there and told them to go back to where they had started.

The blindfolded sighted subjects and the late blind subjects were both fairly accurate, but the early blind subjects were far off. He then obtained their subjective reports by asking them what they did to find their way back. The sighted and the late-blind subjects both gave an answer in terms of some sort of visual spatial image: "We obviously went up a triangle, so I just had to go back

along the hypotenuse." Simple. Early-blind children do not do that, or did not do that in this particular study. They reported they had used time: "We walked for a minute this way and a minute and-a-half this way, so I just walked for two and-a-half minutes to get back," which of course had nothing to do with the direction, the actual vector. Which brought me to the question of time. These early-blinded children were using time as a cue when in fact they were unable to use it properly. They were having difficulties in a very straightforward psychophysical experiment.

### Auditory Functioning

We have also been working on things like dichotic listening and sequential processing of auditory information. You present two stimuli, say two lists of numbers, simultaneously via earphones: 1 and 3, 2 and 7, 9 and 6, and so on simultaneously in pairs, and have the subject report back. At slow rates of speed, the subjects have a tendency to report temporal order. They report first right ear then left, then right, then left, and so on. As you increase the speed of presentation, however, they switch to an ear order effect. Normal subjects will report everything from the right ear followed by everything from the left ear. It is almost as though these inputs were held or stored. You may be familiar with

Broadbent's attentional model. This is what seems to be happening. Late-blind children do the same thing, but surprisingly, the early-blind do not.

Early-blind children stick with a temporal order. It is impossible to handle auditory information when it is coming in at the rate of a pair every quarter-second or every half-second. The channel capacity is limited and that much information cannot be handled. So there seems to be a temporal information processing problem. I am being extremely speculative here. This is just what I am beginning to think, that the behavior that is impaired in an early-blind child is the ability to organize over time, durations of time. If we find cortical degeneration in the extremely long-term study I am doing with rats, I would not be at all surprised to find a certain amount of degeneration in the frontal lobe. Degeneration would be in the visual cortex but I suspect may be found in the frontal as well.

In terms of this rather restricted experimental situation, where I am asking the subject to process input under very demanding conditions, we are getting behavior similar to the sort we observe in children with learning disabilities. This has been viewed lately as tying in with body image and sequential organization of behavior, and also related to impaired sequential organizational processes in patients with frontal lobe damage.

Discussant: Charles E. Rice\*

My work at Stanford Research Institute dealt with auditory perception. I will present data which relate to Dr. Spigelman's comparisons of auditory characteristics of early-blind, late-blind, and sighted individuals.

## ECHO DETECTION EXPERIMENTS

My experiments with echo detection were designed to determine the extent to which an individual could gain information about the environment by the use of echoes. The echoes we are referring to are the result of sounds which the individual himself generates or which are generated for him by engineered sound sources. The echo-perception phenomenon is not difficult to experience although most of us who are sighted are not certain what we are listening for when we talk about echoes.

### Criteria

The initial task was one of asking the test subject to determine whether or not there was something in the environment from which he could hear an echo. Figure 11 (Rice, 1965) shows a picture of the laboratory in which this early work was conducted. You can see that the test subject is seated and that there is an object in front of him, a round circular metal disc (target) in this instance. The task involved the individual generating some kind of sound and then merely answering the question is or is not something there by saying "Yes" or "No." Appropriate experimental controls were used such as trials in which there was no target presented. The acoustic environment was not the normal environment of the individual, but was controlled to reduce ambient noise and the walls of the laboratory were treated to reduce reverberation.

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## Subjects

Under these basic conditions we first employed six test subjects all of whom were late-blind. All were blinded after the age of three. At the time of testing they were in the age group 18-25. While they were seated as in Fig. 11, the target was presented in front of them, they generated a sound, and then based on the echo they obtained they answered yes or no. This was done repeatedly. The presentation method used was the psychophysical method of constants.

This technique established a range of targets which included those the individual could detect nearly 100 percent of the time, and those which were virtually impossible for him to detect. The test subjects used a variety of sounds. Target detectability was measured with the individuals seated at a number of different distances. In Fig. 11 the individual was 36 inches from the target. He was as close as 18 inches



Figure 11. View of the Subject and Apparatus with Target in Position for Judgment

in some studies and as far away as 9 to 10 feet in other instances.

### Performances

Figure 12 (Rice, 1965) shows the detection performances obtained. Each of the curves indicates a different subject-to-target distance. The diameter of the target detected is on the horizontal axis. The vertical axis indicates the percent of correct detections. Using 50 percent detection as an index one can get an idea of the size of the target that was detected at the various distances. There appears to be a very systematic relationship between target size detection and distance. If one moves farther away from the target, the size of the target must be increased in order for it to be detected.

While the previous data was being collected an additional subject served as a backup man in case a subject could not complete the test series. Although our original five completed the task it was decided to test the additional subject. Figure 13 (Rice, 1969) indicates his performance as compared with that of our original sample.

This was subject JK. As you can see, his performance exceeds that of the five original test subjects, and there is no overlap, i.e., he can detect a target at 36 inches, which is a little over an inch in diameter, with 35 to 40 percent accuracy, and reaches 100 percent detection with targets which late-blind subjects can barely detect. This data was sufficiently interesting to us that we tried to find out whether there

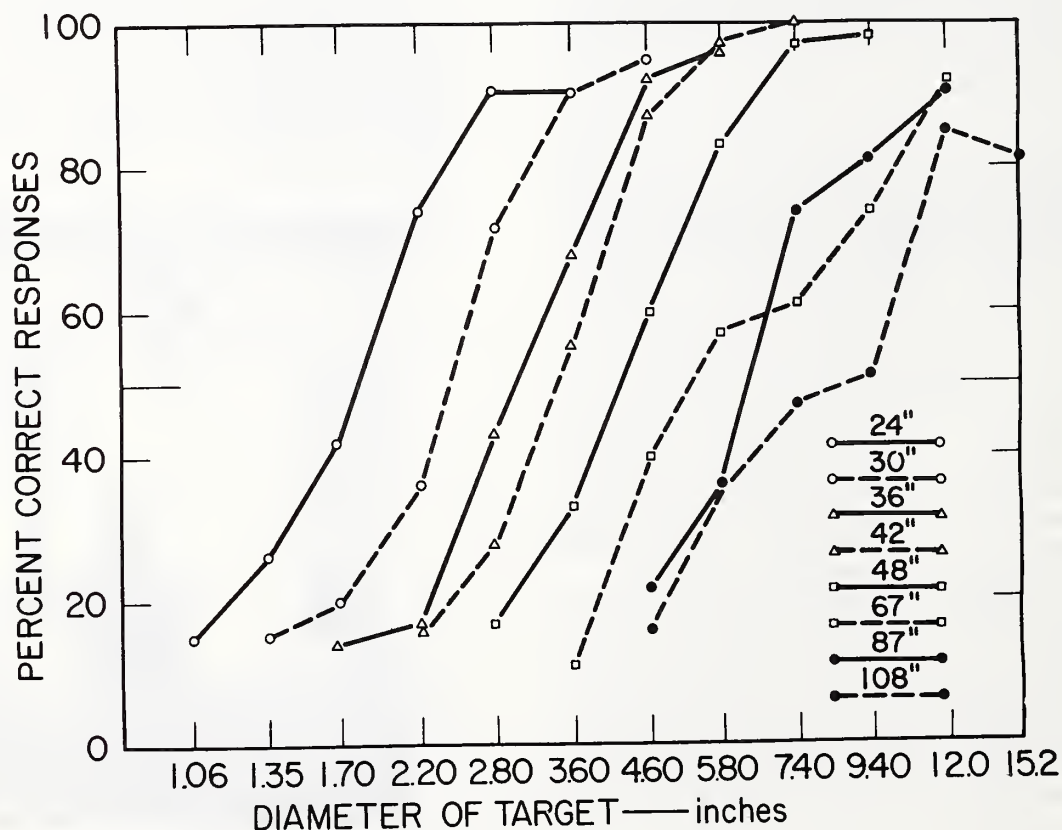


Figure 12. Detection Performances

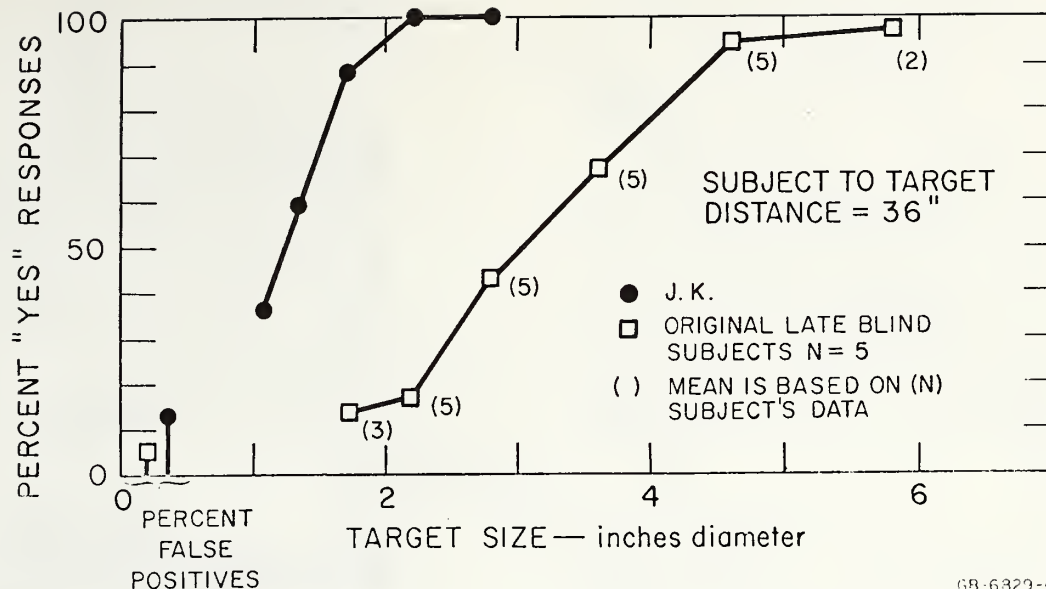


Figure 13. Small Target Detection Performance of Subject JK Compared to Original Late-Blind Group

were differences between JK and the first five subjects which could explain his superior performance. For example, audiograms were obtained for all subjects and educational background and IQ were examined.

#### Early- Late-Blind Performance

The only difference which seemed of possible importance was that JK was blind from birth. It is, of course, necessary to use caution in designating a time of onset of blindness in the very young. In the interest of testing the hypotheses that early blind are superior at echo detecting it was necessary to test a number of early-blind subjects. A sample of early-blind individuals was located. All subjects tested were totally blind. The new group of early blind were brought to the laboratory and tested in the same fashion as the initial group. Figure 14 compares the early- and late-blind subject performances on the detection task.

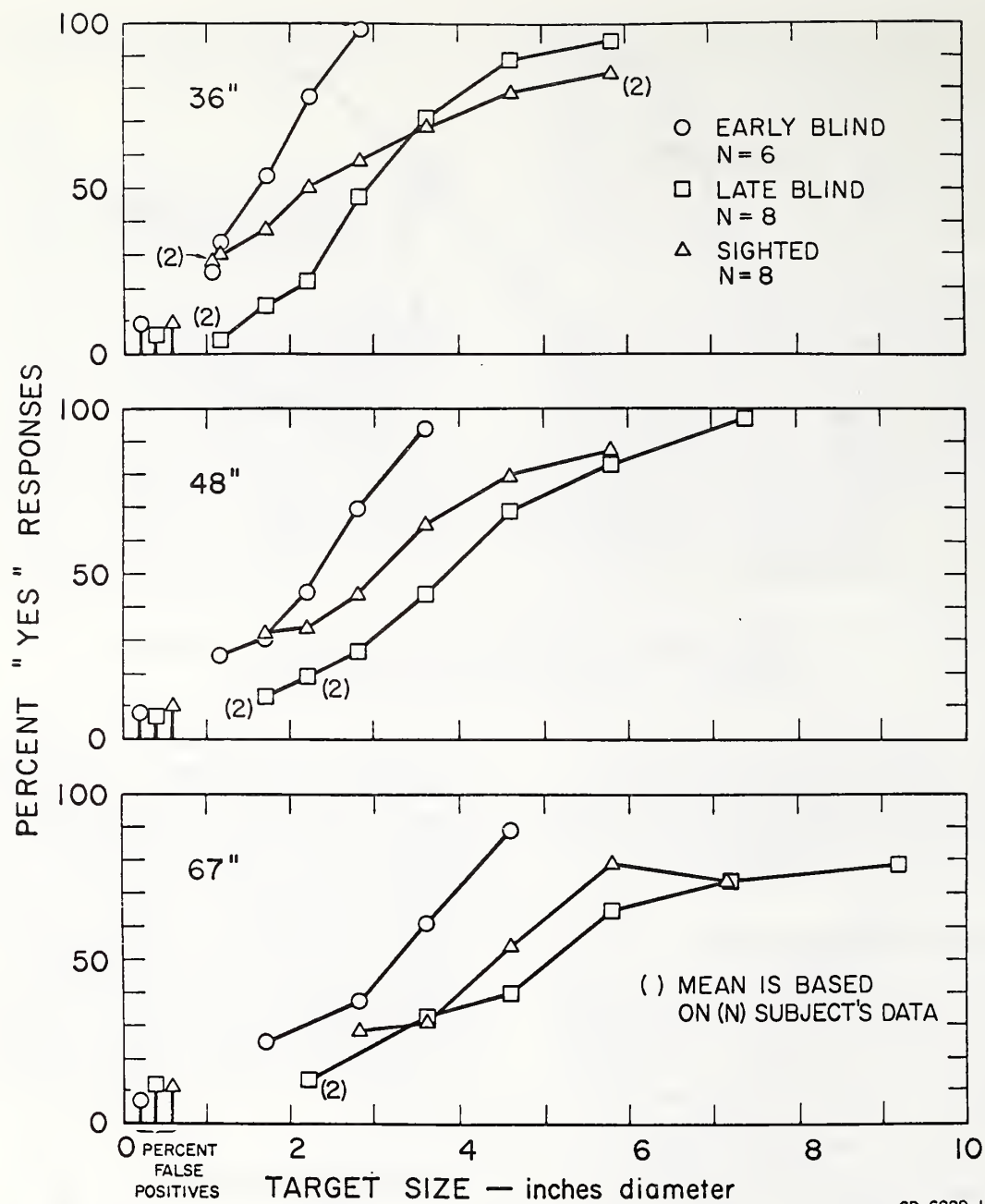
Figure 14 (Rice, 1969) includes comparisons of six early-blind test subjects with eight late-blind test subjects and eight sighted control subjects on the detection task. The data was obtained for three different

distances, 36 inches, 48 inches, and 67 inches. Once again, the performances of the early-blind seem to be superior in this detection task. This stimulated additional examination of the problem, and though we can say at this point it does look like the early-blind are superior at this detection task, there are other questions which need to be answered concerning the test sample, and there are other tasks which could be used in order to determine whether this superiority was typical of all echo perception tasks.

#### Localization of Target

Another test examined a different question, that of localization of an echoing target in the environment. To what extent can these people localize a target when the question is not, is it there, but if it is there, *where* is it. This was done in a laboratory setting which was somewhat similar to Dr. Spigelman's and is seen in Fig. 15.

The individual is seated in a chair as before. His head is held in a metal hat band which holds the subject's head firmly. Any rotation of the head is registered on a scale



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Figure 14. Comparison of Small Target Detection by Early-Blind, Late-Blind, and Sighted Groups

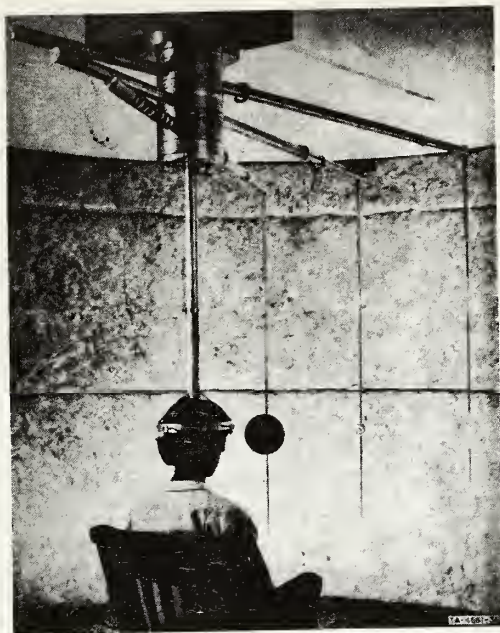


Figure 15. Apparatus for Echo Localization

at the top of the post. With the apparatus it is possible to present targets at any azimuth position. The target is placed on an arm which extends in front of the individual and can be moved to any one of a number of locations on an arc around the head of the subject. The individual is then asked to locate the echo source. In this case, he was asked to locate it by turning his head and pointing his nose at the center of the target. Signals were by mouth, generally tongue clicks. The duration of a tongue click is approximately 50-75 milliseconds. The test was run in several different ways, both comparable to Dr. Spigelman's. In one instance the individual could rotate his head as he wished and in the other instance he had to maintain his head at zero degrees azimuth, emit one click, then locate the target by pointing his nose at the center of the echo source.

There were again false alarm trials, that is, trials in which there was no target and the individual was again asked to locate the target if it was out there, and if not, to say so.

The first experiment asked the subject, with free head movement (he could move his head in any way he

wished and generate as many sounds as he liked) to locate the left edge of the target. The target was 36 inches away. Figure 16 indicates the accuracy of four of these early blind test subjects.

The edge of the target is 5.1 degrees left of its center, and the individuals' responses then are plotted as variation from the left edge of the target. The overall standard deviation was about 5 degrees, indicating that variability from the left edge was not great and that this test group did not miss the target edge very much at all; an average of 2 or 3 degrees.

The results indicate that early blind subjects using an echo perception method to localize an object in space are more accurate than Dr. Spigelman's results would imply.

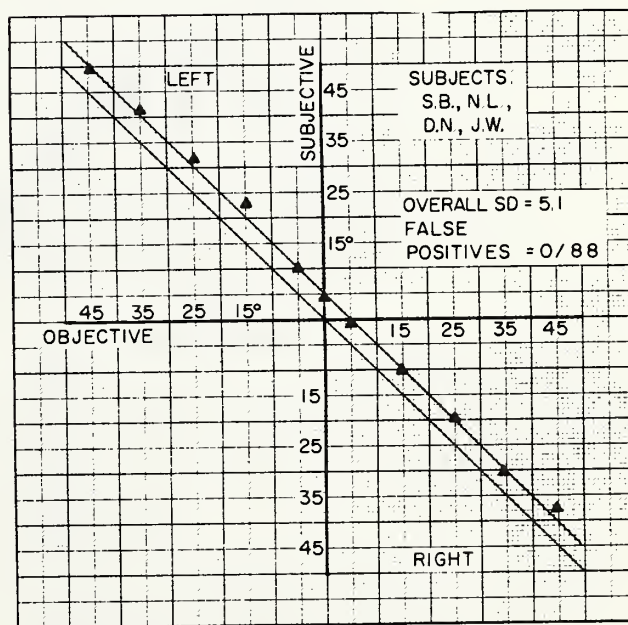


Figure 16. Localization: Left Edge of 6.4-inch Target at 36 Inches with No Feedback, 20 Trials/Objective Azimuth Run. Group Mean Subjective Azimuths.

## Locating Target Position

Data more directly comparable to Dr. Spigelman's is generated in another test in which the individual was asked to generate a signal at zero degrees, then maintain silence and move his head to the position where he thought the center of the target to be. Comparisons were made between the early-blind, late-blind, and sighted, and results appear in Fig. 17 (Rice, 1969).

The absolute position of the target was indicated by figures on the horizontal axis. The vertical axis was the measure of the subject's accuracy; where his nose actually

pointed in the test. Data was recorded for the early-blind, late-blind, and sighted test subjects. The solid line with the circles indicates the mean judgment for the early blind group. The numbers beside each data point are indicative of the number of test subjects contributing to the mean. There is comparable data for the late-blind and sighted test subjects.

Data indicate that most of the early-blind people generating a single click signal straight ahead were capable of detecting a target over almost the entire 180-degree range, and were more accurate at locating the center of the target. When

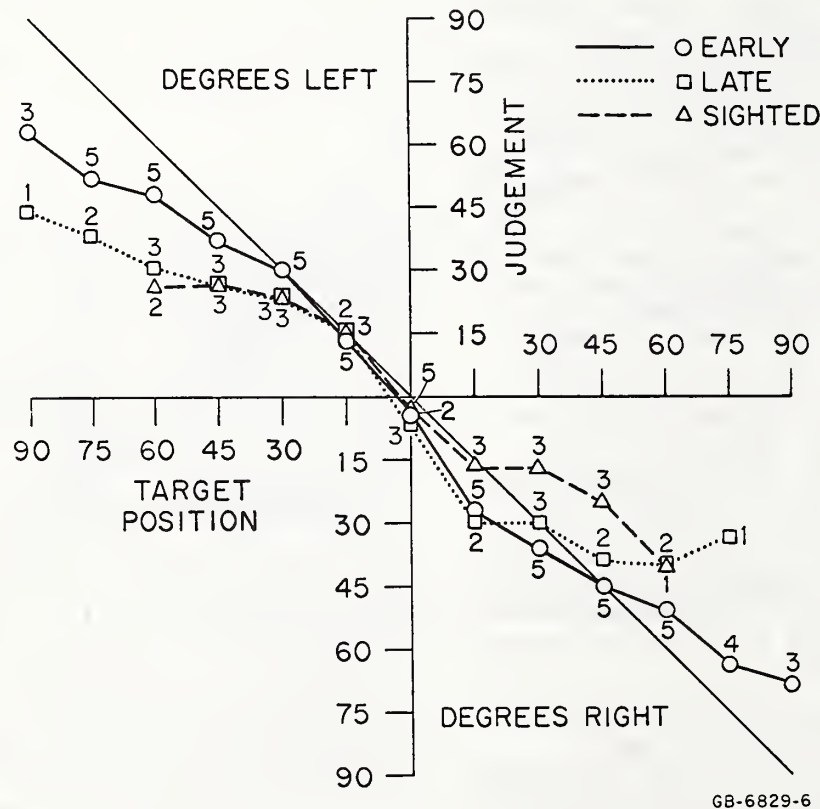


Figure 17. Mean Judgments of Target Azimuth with Respect to True Azimuth for Early-Blind, Late-Blind, and Sighted Groups

beyond 60 degrees in either direction, the sighted group no longer is capable of detecting the target with accuracy or regularity. The late blind seem to be able to detect the target farther in each direction, but again are less accurate.

#### Discrimination of Changes in Origin of Echo

One other task which I think is relevant here is whether, when an individual can locate a target, he can also discriminate small changes in origin of the echo. To determine this we used a testing procedure which is comparable to Mills' study of the minimum audibel (Mills, 1958). The procedure involves placing a target in space, allowing the individual to echolocate the target, then move the target slightly in one direction or the other, generate another signal, and then judge the target in the same position, to the left, or to the right of the original zero-degree position. Blind test subjects were able to detect reliably a deviation of only 4 degrees with targets 36 inches away. Again, this indicates considerable accuracy in auditory location by blind persons and is contrary to Dr. Spigelman's conclusions.

I think in fact this provides a sufficient amount of data to conclude that my results and those of Dr. Spigelman do not agree. I would like to talk for a few moments about possible resolutions of these differences.

#### DATA DIFFERENCES IN TWO STUDIES

Let us examine whether some of these differences between Dr. Spigelman's data and mine can be resolved or rationalized. His tests were done over a complete arc of 360 degrees. This is a different task. There are more options open to the test subject, and there is therefore a reduction in probability of correct responses occurring by chance. The other difference, of course, is the method of indicating the sound source in space. In Dr. Spigelman's study a motor response of fingers located the position of the target and indicated it by pushing a button. In my studies

actual pointing of the nose was involved. I think this may account for some of the differences. I propose that by the individual pointing to the target with his nose there is less in the way of cognitive interference with the location of the sound source. He now no longer needs to think about the position of the sound source, find the position tactily on a display and then indicate what that position might be, possibly making some errors in that process in addition to motor errors. Why this would be any more difficult for an early-blind person than for a late-blind person again, I don't know.

Of course, another difference is that the echo source is a different source than a pure tone source sounded in space. There are differences, depending upon the frequency, in one's ability to localize a sound in space. The sound spectrum of the echoed signal and tongue click is virtually a noise spectrum, and a noise spectrum is a sound source more easily located than a pure tone. There are other differences. Although Dr. Spigelman does not discuss it in his paper, I want to ask him about the acoustic properties of his laboratory. Whether, for instance, he attempted to reduce the reverberatory characteristics of the laboratory, and whether he could isolate the laboratory from external noise or not. If not well controlled, those factors can have the effect of decreasing accuracy. Of course, my laboratory did have a stationary setting, and if we could have combined our lab with his mobile facilities, in many ways it would have made for an optimal test situation.

Dr. Spigelman tells me that his laboratory was a house trailer. That increases the possibility of standing waves which would definitely influence the localization accuracy, although I do not know that it would account for differences in early- and late-blind subjects.

Dr. Parmelee asks me to clarify one part. It appeared that within 30 degrees to the right and 30 degrees to the left, or over a 60-degree arc, there was no statistical difference between any of the groups. This suggests that arc discrimination within a narrower range is the same in all

groups. Proceeding in 5-degree increments, all would do equally well until they got beyond 30 degrees to either side. In other words, they can discriminate. Is it just a question of range laterally? I would agree that there does not appear to be any difference between the early-blind, late-blind, and sighted for that particular arc. I think that the difference comes in the ability to recover echoes from a broader arc.

I cannot agree to the suggestion that all groups were the same through the 60-degree arc. I would say that the ability to recover information and localize its source extends beyond that point for the different groups differentially, and that the early-blind are more successful in identifying the presence of the source and also locating it beyond that point.

In my late-blind sample, as in Dr. Spigelman's, no subject was blinded earlier than three years of age. Yet some of the late-blind had been blind longer, in time, than some of the early blind. The sample, I think is a point of difference which offers an opportunity for greater resolution of the difference between the two studies. I think that insofar as we can talk about a reasonably representative sample of early-blind test subjects, Dr. Spigelman's group is more likely to be representative of that group than my own. In this research, which was a long term series of studies, the laboratory was in a remote area. When we employ blind people, we employ them with the anticipation of keeping them from 1 to 5 years, in a series of studies of this nature. So we had to require that these people be pretty mobile, willing and able to use public transportation and to conquer any difficulties over that long period of time which might prevent them from getting to the laboratory.

We had a sample of early-blind test subjects (and the same would be true of the late-blind test subjects) who are representative of a group used to overcoming travel difficulties. I think that this represents a considerable biasing of the sample. When we decided that these late-blind/early-blind differences might be real, and that the early-blind might be superior, we began to talk with others,

particularly those interested in mobility of the blind at San Francisco State University. We talked about an adequate and accurate description of early-blind individuals. The consensus of opinion was that the sample was extraordinary, and that there may even be a bimodal distribution, that there are those who are extremely active, extremely mobile, and there are those who seem to have great difficulty with mobility and orientation. We were unable at that point, to find a sufficient number of early blind test subjects to answer the question.

We were able to find one poorly orienting test subject and bring her to the laboratory and run her through many of these same tests. Of course, one test subject is insufficient. However this one test subject reinforced the idea that the bimodal hypothesis should be investigated further. The test subject was at a total loss in the laboratory. From her academic record and case history she appeared to be normal except for blindness, but from an orientation and mobility point of view she was severely handicapped. Anecdotally, I would like to point out a couple of specific differences. It was very difficult for her to find her way from our subjects' waiting room to the laboratory, which involved going through two doors, out an exterior door, along a sidewalk, up some stairs, and through another set of doors. Although given probably 10 times as much guidance and instruction as any of our other early-blind test subjects, she still would come out of the waiting room door, make a wrong turn, go along the sidewalk, perhaps making wrong turns there, and then would touch each step as she went up the stairs.

The contrast between this test subject and our other early-blind test subjects makes a major point. With the first group of early-blind people, the single word which would describe them best is "adventurous." They were continually seeking stimulation. They were continually and intrepidly trying to reach out and find new things to examine, even to their own detriment. We had to hide all ladders in the laboratory complex, for instance, because as soon as they came upon a ladder they went up to find out what was at the top.

There is also a compound for seals and sea lions in this laboratory. Sea lions make a lot of noise and our early-blind test subjects were drawn to them. We had to put locks on the gates of the sea lion compound, because no matter how many

times we would tell them, they were always going over, opening the gate, and wanting to find out what a sea lion is like. These are just a few illustrations, but they are characteristic of this particular group.

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## General Discussion

Dr. Bach-y-Rita reported that his own experience with subjects in the vision substitution studies confirmed Dr. Rice's observations on the relationship between echolocation and mobility. The older, most mobile individuals did use echolocation. In fact they had discussed this with the others and were in the process of trying to develop means of training for it. They found this was the crucial difference between those who were mobile and those who were not. They did not quite know the mechanisms for learning echolocation, though, and were working on it. Dr. Rice felt that this would probably be difficult. Echolocation was obviously difficult to learn at an early age and only some children somehow hit upon it. It may not be hard to learn once you know what to attend to. The crux of the problem was how to teach an individual to attend to echo sources.

Mrs. Fraiberg said she was not sure to what extent their own observations were relevant here because the arguments of Dr. Spigelman's and Dr. Rice's papers were very complex. It was the developmental aspects which had been of particular interest to her group.

### SOUND LOCATION

The ability to reach on sound was a late achievement in the first year, and this applied to all of the children they had studied. There is no adaptive substitution of sound for vision. If one considered that under the most favorable circumstances the children they observed did not reach on sound until late in the first year, this was already a major factor.

### TRACKING

Second, in the normal development of sighted children there is already in the second month what Piaget calls a turning toward the source of

sound with the expectation that a visual spectacle would present itself, so that the early coordination schemas are practically guaranteed by vision itself. Now with these blind children, as mobility developed early in the second year, one did begin to see tracking. There was tracking of mother's footsteps, tracking of mother's voice, and many very sophisticated forms of tracking.

The more mobile and active children--and this was actually most of their sample--were tracking successfully and also mapping very successfully on the basis of sound. They were not taught echo techniques. One would assume they were using them in some way, but they became available to the child through his own pursuit, as it were. Sound connoted substantiality, or connoted important people, mother particularly. This provided a basis for inferences as to the sound of inanimate objects and other sound-making sources which made a very complex range of tracking experience available to all the children.

### RADAR TECHNIQUE

There was also something one of the staff called the blind child radar technique. There are moments when the blind child in the second or third year is cut off from all sound experience, and for a moment there are no indicators of the presence of mother or of other familiar people. He will then use the device of saying "mama" or someone's name, calling out to orient himself on the basis of a response, and very possibly an echo too. This develops quite spontaneously in normal, healthy, curious, active, mobile blind children.

Dr. Rice commented that in his opinion the important thing was to find out whether a child could be taught to use sound as a probe, perhaps the earlier the better.

Optimal use of the auditory process would give the child a very significant input which could lead him to be a more normal, mobile, exploratory child.

## TEMPERAMENTAL TYPES

Dr. Chess stated that it might also be very interesting to divide the early-blind subjects into two temperamental types. Those temperamentally slow to adapt to new stimuli would be exemplified by the subject described by Dr. Rice, who had to be sought out. On the other hand, there would be those who approach new stimuli. This was the kind of temperamental differences she and her co-workers had found in normal children and in retarded children and in their rubella children. She felt that Dr. Rice had given a very vivid description of those who approach new situations with ease, and that could be where the difference lay. Dr. Fowler added to this that he had been involved in a study which was relevant to what Dr. Chess was defining as temperament: the issue of some children reaching out more. This was a study at Yale some years ago on poisoning deaths in children two to four years of age. They discovered that there was a very high correlation between children who got into things and explored poisons along with other parameters of the environment, and the permissiveness with which they were reared. Many of the values which we put forth as good for children's development in encouraging exploration got these children into poison because the environment was not suitable for a child.

In the rearing of blind children there might be a natural overprotectiveness which would tend to keep parents from encouraging children to explore the environment. The interaction here between the reaching out and the specific learning of the mechanism of echo localization would seem to be a fruitful avenue of research.

## SOUND LOCALIZATION AND OTHER PROFICIENCIES

Dr. Spigelman said that he had done some incidental studies while at the school for the blind, with the aim of examining the relationship of sound localization to other proficiencies. In one, a rating scale was given independently to the physical education teachers and mobility instructors and they were asked to rate all of the 36 blind children from the original study. The rating was in terms of body orientation and mobility, such activities as being able to find their way downtown and back. Nothing was said to the raters about the children's performance in the experiments. The correlation between the degree of localization and the independent ratings of orientation and mobility was very high. It ran in the high 0.8's. What is more, there was no overlap between those two distributions. So the child who was a poor localizer was also a poor orienter.

He had also tried to relate each student's localization score to his grade history (the school goes up to grade 12). Courses like geography and geometry were taken as being spatial, versus history and literature, non-spatial. The poor localizers turned out to be weak in geography and geometry. They were always failing. But they did well enough in things like history, music, and literature, and there was no difference between early and late blind.

On the subject of comparisons between early and late blind, Dr. Rice said he wanted to add to his earlier statement that he had found the early blind superior in echolocation. In the course of his research they had tested one more sighted subject, 18 years old, and her performance was just as good as that of the early blind. What did that indicate? They investigated the circumstances of this one sighted subject's early experience, and it turned out to be a special case. This girl was an Indian from North Carolina. Her father was a sharecropper in a rural area. At the

time she was born there were no electric light bulbs in the house and it was the custom of the family that the child be placed in a quiet room in darkness in the first year of life, or at least for the first few months. This was not the kind of thing that one could publish, but he felt that anecdotally it did make an interesting point. The conclusion he drew from this case was that we were not getting sensory enhancement or sensory compensation. What we were really getting was sensory optimization.

## HETEROGENEITY OF BLINDNESS

Dr. Chase cautioned that one must pay close attention to etiological differences when working with blind human subjects. She recalled what Dr. Parmelee had pointed out during the discussion of the Adelson and Fraiberg paper regarding the heterogeneity of blindness. Dr. Chase felt that a level of sophistication now existed in this area which enabled one to focus very specifically on diagnosis. There were two groups in Dr. Spigelman's study. The early blind group was largely an RLF group and the later blind group was largely a retinoblastoma group. In the work with retinoblastomas which she was doing with Dr. Witkin and others, this was found to be a very unique genetic population. Retinoblastomas had characteristics that made their learning style quite different from other groups. As for retrolental fibroplasia, we now have considerable evidence of additional damage over and above damage to the retinas. She felt that in drawing conclusions in this area one had to take into account these fine differences. In moving from rats, where one has a controlled case of enucleation, to humans with various etiologies, it is necessary to exercise a great deal of caution as to what group one is discussing and what was the cause of blindness.

Dr. Rice pointed out that the researcher looking at the kind of problems he and Dr. Spigelman had studied would not be able to do any research if he could not specify some kind of sample. But if one began to break it down into what kind of blind group were to be used it would be

impossible to get enough people to test in one geographic location. Dr. Chase agreed that this was the case. They were having a great deal of difficulty getting the retinoblastoma sample. However, any generalization to "the blind" must then be very carefully and explicitly circumscribed. Dr. Rice concurred; one could not generalize freely, but what one could do was to generate hypotheses which could be tested in terms of general rules; so that if, in this instance, capacity for sound localization is a function of early experience or of training one could make some progress by studying the populations which were available.

## RETINOBLASTOMA STUDY

Dr. Chase also reported that in the retinoblastoma study they obtained attention concentration findings similar to those of Dr. Spigelman. They had tried to devise a pure auditory disimbedding task and could not. The one they did devise and use turned out to be not a pure auditory disimbedding task but an attention concentration task as well. She thought this factor was contributory, and one did find differences in early blind populations with regard to this factor.

## BLINDFOLDING

Dr. Chase questioned the expectation that by blindfolding sighted subjects one is indeed making any stylistic change in their means of responding. It is very different in terms of the attention concentration factor, to take even someone who is late blind and only has been blind for a short period of time, or to take someone who functions as a sighted individual and blindfold him. She did not think one could equate the visual input systems of those groups. The tendency to blindfold as a research method is a practice which needs to be questioned at the level of the assumption involved.

Dr. Bach-y-Rita added that we should also keep in mind a related point regarding many total blindness studies such as those of Hubel and Wiesel in which they sew an eye closed in order to study effects on neural

function when that eye is opened later. These do have light through the lids, and this is usually forgotten. Any neural changes should be evaluated in that regard, that there is light input during the period of supposed blindness.

## SPECIFICITY OF DEPRIVATION EFFECTS

Dr. Prescott recalled Tees who did two beautiful studies in the auditory and visual senses in which patterned stimulation of both these systems was reduced. For example, in the auditory system, earplugs were used and animals were reared under pure tone and tonal pattern conditions. No difference was found in the animals' ability to discriminate pure tone frequency. However, there were major differences in their ability to discriminate tonal patterns.

Mrs. Ling objected that if one put earplugs in, the amplification level was merely lessened. The sense was not actually eliminated. This was another case like sewing the eye, which is very different from actual blindness. However, while he readily admitted this, Dr. Prescott felt that the point of the study was that the nature of the sensory input during the early periods is related to the kinds of test procedures that have to be used to pick up any deficit.

## SPECIES CHARACTERISTICS

Dr. Rice brought up the question of species characteristics. It was difficult to generalize from rat data in the sense that if one blinded a

bat, for instance, and did the same study, one would have quite different outcomes.

Dr. Parmelee mentioned circadian variations. Rats are generally active at night. If they were tested in the daytime there would be a diurnal effect which might be less incapacitating to the early blind. In biochemistry it makes an enormous difference whether you are testing at night or in the daytime. Dr. Spigelman replied that he usually did the testing around 6:00 every morning so as to be finished by about 11:00, since the lab was not airconditioned. There are two activity peaks, one at around 2:00 a.m. and another at around 6:00 a.m. So he was just beginning to test during the second one.

## EAR PREFERENCE

In reply to a question from Dr. Spigelman as to whether he had ever found ear preferences, in particular right ear preference in the early blind, Dr. Rice said he had not looked at it systematically. He could only give anecdotal evidence indicating that some test subjects did seem to prefer to listen with one ear more than the other. It could be interpreted that way, or one could say that they were looking for contrasts between the ears in reception of an echo. If the target were at zero-degrees azimuth, some preferred to generate the signal off 15 to 20 degrees to the left, and they performed quite well. He did not have sufficient data to indicate whether in those subjects who did demonstrate a preference (if preference there was), there was a preponderance of one group over another.



### Third Session

## SOMATOSENSORY DEPRIVATION AND ITS RELATIONSHIP TO THE BLIND\*

Formal Presentation: James W. Prescott\*\*

The objective of this paper is to illustrate how a visual defect can result in deprivation to the somatosensory modality and that behavioral deficits usually attributable to the primary visual sensory deficit may, in fact, be attributable to deprivation of the somatosensory system. It is suggested that this type of confounding may also occur when other sensory channels suffer deprivation. Neurobiological and neurobehavioral principles derived from animal sensory deprivation studies are briefly sum-

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\*The original presentation included a showing of films and slides accompanied by informal commentary. The present article is a more structured presentation with more recent data of these ideas and hypotheses that relate somatosensory functioning to blindness.

It should be recognized that this paper is primarily a theoretical and speculative venture to link a number of different issues from several disciplines within a common frame-of-reference. It is acknowledged that certain points of view have limited support from experimental data, however, it is hoped that this conceptual effort may prove heuristic in developing new research approaches to some basic scientific questions that have unusual relevance for human development.

\*\*National Institute of Child Health and Human Development.

*The viewpoints expressed in this article are those of the author and do not necessarily reflect those of the National Institutes of Health or the U.S. Department of Health, Education and Welfare.*

marized in order to clarify the meaning of behavioral symptoms occurring in humans who also have been deprived of sensory stimulation during early development.

### SOCIAL DEPRIVATION AS SENSORY DEPRIVATION

A major conceptual dilemma characterizes a number of studies on the effects of early experiences upon development. Specifically, studies of infants separated from their mothers have been characterized as "maternal-social deprivation," "perceptual deprivation," and/or "emotional deprivation." In addition to the error of using the term "maternal" rather than "parental" there has been little effort to describe the separation experience in terms of specific sensory processes. Unfortunately, noted authorities in this area of research have used language to describe their experiments in a way which has led to a conceptual differentiation of *social development* from *neurobiological development* and consequently, the sensory processes that are common to these two disciplines have been neglected.

The failure to conceptualize the studies of "maternal-social" deprivation and isolation rearing within a neurobiological frame-of-reference for *sensory deprivation* can be attributed in part to the orientation of H. F. Harlow [1] who stated:

"The most extreme deprivation condition we have studied is total social isolation (not sensory isolation, only social isolation). The animal has no mother figure of any kind; also it has no opportunity to see, hear, or contact any other animal or even a human being, for during the isolation period it is fed and tested by remote control. Thus these animals have no chance of developing any affectional tie." ([1], p. 154.)

The distinction between social and sensory deprivation was also emphasized by Casler [2] in his review of the effects of "maternal" deprivation where he stated:

"One may agree that it is social rather than perceptual or sensory deprivation that is involved in these cases." ([2], p. 23.)

This point of view, or conceptual schema, has received support from another noted authority in "maternal-social" deprivation, namely, R. A. Spitz [3], who states:

"In conclusion, I call the reader's attention to the terms I have used in dealing with this subject. I have spoken advisedly of *affective* (emotional) deprivation. In recent years a great deal of illuminating and interesting work has been done with animals and humans on the effects of sensory deprivation. . . it should be realized that sensory deprivation and emotional deprivation are not interchangeable concepts. Granted, in the present state of the art, it is practically impossible to inflict the one without involving the other . . . accordingly, I believe that further experimentation and study will be required before we can delineate the nature of the two forms of deprivation and isolate their effects from each other." ([3], pp. 281-284.)

This disassociation of affective (emotional) processes from sensory processes is also evident from Spitz's discussion on infant perception. He states:

"Particularly during the first six months of life, and, to a certain extent even later, the perceptual system, the sensorium of the infant is in a state of transition. It shifts gradually from what I have called coenesthetic reception toward diacritic perception. The sensorium plays a minimal role in coenesthetic reception; instead, perception takes place on the level of deep sensibility and in terms of totalities, in an all-or-none fashion. . . . Furthermore, perception through the sensorium (diacritic perception) does not yet operate; this absence of diacritic perception intensifies coenesthetic 'reception,' since only coenesthetic signals will be received, experienced and become effective." ([3], pp. 140-41.)

Spitz's distinction between coenesthetic reception and diacritic perception is made even more clear by the following:

"It is my opinion, however, that a large proportion of the pathways involved belong to a system of 'sensing' basically different from the system of perception that operates at a later age and with which we are familiar. I have discussed the nature of these two systems and the differences between them elsewhere (Spitz, 1945, [4]) and have called the one present at birth the *coenesthetic* organization. Here, sensing is extensive, primarily visceral, centered in the autonomic nervous system, and manifests itself in the form of emotions. Accordingly, I prefer to speak of this form of 'perception,' which differs so fundamentally from sensory perception, as reception. It is an all-or-none phenomenon operating as a binary system.

In contrast to this stands the later development of what I have called *diacritic organization* where perception takes place through peripheral sense organs and is localized, circumscribed, and intensive; its centers are in the cortex, its manifestations are cognitive processes, among them the conscious thought processes." ([3], p. 44.) (See also Spitz, 1945 and 1946 [4-6].)

It is clear that Spitz views the emotional (affective) processes as primarily a visceral process localized in the autonomic nervous system and unrelated to sensory mechanisms and higher brain processes. This unusual psychoanalytic interpretation of the neurobiology of emotional processes which denies the primacy of sensory mechanisms and higher brain processes in these functions can have only contributed to a misdirection of scientific thought and research on the neurobiology of emotional ("maternal-social") deprivation phenomena.

The continuing distinction between social, emotional, and sensory processes in "maternal" (parental) deprivation phenomena has contributed to a lack of clarification of mediating mechanisms which is reflected in Yarrow's [7] summary of the effects of maternal-social deprivation:

"We can only speculate on the processes through which the mother comes to acquire special meaning to the child." ([7] p 486.)

This writer advocates a sensory-neuropsychological orientation to the study of parental deprivation and isolation rearing phenomena. Studies reviewed below and elsewhere have led this writer to the conclusion that the somatosensory system (cutaneous, visceral, proprioceptive and vestibular afferents) is the sensory modality that mediate the abnormalities consequent to isolation rearing; and that deprivation to the other sensory modalities during the formative periods of development will not lead to abnormal social-emotional behaviors provided somatosensory stimulation is present.

From the above it would seem appropriate to suggest that it is timely to move from speculation "on the processes through which the mother comes to acquire special meaning to the child" to basic research on the sensory processes in the parent-child relationship.

It is recognized that many investigators have acknowledged the importance, if not the primacy, of physical contact in isolation rearing studies and the Harlows' emphasis on "contact comfort" attests to this recognition [8-10]. Mitchell [11] summarizes this point of view succinctly:

"Rearing in *social* isolation produces severe behavioral pathology in all primates. The most important source of stimulation that is absent in such a rearing condition is physical contact from another animal involving a complex combination of skin or fur contact clinging, movement, oral contact, and warmth."  
([11] p. 243.)

Unfortunately, the phenomena of "physical contact" in primate behavioral studies has been restricted to the conceptualizations of "social" behavior and thus has distracted from a *neurobiological* interpretation which could have led to systematic studies of sensory processes and brain functioning which tragically are still lacking today in the isolation reared primate.

The theoretical orientation outlined above does not deny the importance and relevance of the other sensory modalities in the normal development of social relationships. It is the conviction of this writer, however, that the affective/emotional component of social behavior is mediated by the somatosensory system (near receptors) and not by the visual and auditory systems. These latter modalities (distance receptors) do, however, acquire the capability of triggering emotional behavior. This is accomplished through a complex developmental conditional learning process which involves sensory integrative mechanisms. Whether the sight or sound of the parent (conditional stimuli) triggers positive or negative emotional responses in the child is dependent upon the history of the quality of parent/child somatosensory relationships, namely, pleasure or pain (unconditional stimuli).

It is the belief of this writer that the "psychological" or "psychosocial" environments must be understood in terms of their transformation into sensory experiences that are perceived by the organism. The alternative is to invoke extrasensory perception or non-sensory (spiritual) experiences in the development of social relationships and behaviors.

## EFFECTS OF EARLY SENSORY DEPRIVATION

A number of studies have clearly documented that sensory deprivation during formative periods of development can result in failure of the deprived sensory system to develop and function normally; in such cases neuroanatomical, neuroelectrical, and neurochemical abnormalities have been described from the level of sensory receptors through sensory relay nuclei to the cerebral cortex [12-43; 50]. Conversely, enriched sensory stimulation during the formative periods of development can result in increased growth of the sensory system that has been enriched [33-42].

Special attention is drawn to the study of Volkmar and Greenough [38] since they demonstrated significant differences in higher order dendritic branching in Layer V pyramidal neurons in visual cortex between rats reared in groups in a complex environment and litter mates *reared in pairs in normal laboratory cages*. Differences were also found with litter mates reared in single cages (isolation condition). Further, these animals were not assigned to experimental treatments until they were 22 to 25 days of age. Two important conclusions can be drawn from this study:

1. It is clear that an enriched environment when compared to a *normal social control environment* is sufficient to produce significant structural alteration of brain cells. It does not require extreme sensory deprivation to produce these effects upon the brain;
2. These animals did not require differential rearing environments *from birth* to produce structural alterations in the brain. Consequently, neither severe alterations in the sensory environment nor deprivation in very early life are required to produce structural alteration of brain cells.

Greenough, et al. [39] have extended the findings of the above study by demonstrating that rats reared in *complex environments* had significantly more basal dendritic branches in the temporal cortex than those from *littermates reared socially or in*

*isolation*. No significant differences due to rearing were detected in the frontal cortex. They conclude that the effects of environmental complexity on dendritic branching are not restricted to those previously seen in the visual cortex and that the specificity of effects rules out generalized influences that could be expected from hormonal or nutritional differences. Greenough and Volkmar [40] are more explicit on these interpretation of differential rearing effects.

"The results suggest that the differences in dendritic branching seen after rearing in complex environments are a function of this complexity, rather than of visual deprivation, and indicate a mechanism whereby the effects of the early environment may be expressed in later behavior." ([40], p. 491.)

A similar point of view has been expressed by Rosenzweig, et al. [34].

These findings must raise questions about the effects of moderate sensory variations upon brain development in higher mammals, specifically, primates. It can be concluded that the immature mammalian brain at birth and throughout its period of immaturity is dependent upon sensory stimulation for its normal growth, development and function. Sensory stimulation is like a nutrient and just as malnutrition adversely affects the developing brain so does sensory deprivation [35, 36].

Studies of sensory deprivation have revealed not only the above developmental neurobiological principle but also a developmental neuro-behavioral principle. Specifically, animals that have been deprived of sensory stimulation during the formative periods of development will as adults engage in stimulus-seeking behaviors, as if to maximize the sensory stimulation that they were deprived of during early development. This behavioral phenomenon has been previously referred to as a "neurophysiological addiction" for sensory stimulation [37]. Based upon Riesen's [13; 15] observations and suggestions that Cannon's Law of Denervation Supersensitivity [44, 45] may be related to environmental sensory deprivation effects, this writer has proposed that denervation supersensitivity is

the neurophysiological mechanism underlying stimulus-seeking behaviors consequent to early sensory deprivation, i.e., partial functional deaf-ferentation [44-47]; Sharpless' review on denervation supersensitivity and its relationships to behavior should also be consulted [48].

Lindsley, et al. [49] have reported that visually deprived monkeys will bar press over a thousand times per hour to receive light stimulation and that they show enhanced electro-cortical responsivity to lights *on* and *off*. Similarly, Arnott's\* study described elsewhere [37] also reported that cats born in darkness and remaining in a totally deprived visual environment for one year would bar press continuously for light stimulation from eight to twenty hours per day or hold the bar down permanently until fatigue intervened. These animals were tested after being deprived of food for 24 hours and had a choice to bar press for food or light. The studies of Butler [51, 52] and Butler and Alexander [53] also document the increase in visual behaviors subsequent to visual deprivation.

Similar stimulus-seeking behaviors are well substantiated for the somatosensory system. Melzack and Thompson [54] and Melzack and Scott [55] have reported the hyperexcitability behavior of dogs reared in isolation where body contact, touching and movement stimulation from other animals and humans were virtually nonexistent. Riesen [56] has shown that normal environmental stimulation after severe early sensory deprivation of isolation rearing can result in (a) hyperexcitability, (b) hypoexcitability, (c) increased susceptibility to convulsive disorder, and (d) localized motor dysfunction. The instance of hypoexcitability occurred when an animal developed severe response inhibition which resulted in death. The studies of the Harlows' [8-10] and their many students and colleagues have amply documented the self clutching, rocking behaviors, thumb, toe, and penis sucking and cage "swirling" in isolation-reared monkeys. This writer has interpreted these behaviors as a consequence of somatosensory deprivation which induces dysfunctional somesthetic and

vestibular-cerebellar activity. Cannon's Law of Denervation Supersensitivity might be a relevant explanatory neural mechanism for these dysfunctions. Thus, stimulus-seeking behaviors have been documented in another sensory modality (the somatosensory) as a consequence of deprivation in that sensory system and additional examples have been given elsewhere [35, 36; 57, 58].

## VESTIBULAR-CEREBELLAR MECHANISMS IN ROCKING AND HYPERACTIVITY SYNDROMES

It would appear helpful to illustrate how Cannon's Law of Denervation Supersensitivity might account for the perseverative rocking behaviors of isolation reared monkeys and institutionalized children. Under these social-environmental conditions it is proposed that neither infant monkeys nor children receive sufficient body contact and movement by being picked up, handled, and carried, as evidenced by their movement stereotypes. Consequently, both somesthetic (touch) and vestibular (movement) sensory receptors and their projections to other brain structures do not receive sufficient sensory stimulation for normal development and function. If Cannon's Law of Denervation Supersensitivity applies to the CNS, then the sensory projection fields in the cerebral and cerebellar cortex, and other neural structures receiving somatosensory afferents would become supersensitive, hyperactive, and hyperreactive in function. It is suggested that these conditions may result in an excessive output from cerebellar cortex through the Purkinje axons which are exclusively inhibitory in nature. These cerebellar cortical efferents impinge directly upon a variety of brain structures including the deep cerebellar nuclei [59]. The cerebellar cortical efferents could directly inhibit those brain structures involved in the transmission of neural impulses associated with rocking. Consequently, the rocking behaviors would continue since the appropriate brain structure(s) would not receive the sensory stimulation generated by the rocking behaviors and the presumed "instruction" to "stop rocking." In other words, the rocking behaviors are non-functional and so rocking continues.

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\*Personal communication.

If the above theoretical neuronal model to account for perseverative rocking and movement behaviors has any validity, then the following procedures should bring about termination of the rocking and movement stereotypes. One strategy involved the neurosurgical removal of the presumed abnormal cerebellar cortex (cerebellar decortication) which would eliminate the cerebellar cortical inhibition of the vestibular nuclei and other brain structures to which it projects. Berman [60, 61], and Berman, et al. [62] performed a series of cerebellar decortications in rocking isolation-reared infant monkeys and violent isolation-reared adult monkeys. In the few animals that were operated upon, a dramatic reduction in rocking time occurred without observable motor impairments except for one animal (the nature of this specific deficit has yet to be determined). Also, violent behaviors in adult animals receiving a midline vermis decortication were eliminated. The adult animals receiving a lateral hemispheric decortication continued to behave violently [62]. These preliminary neurosurgical studies provide some support for the role of the cerebellum in mediating rocking behaviors and impulsive, violent-aggressive behaviors. These findings illustrate how little we know about the neurophysiological mechanisms that mediate perseverative rocking behaviors.

The second procedure involved intense vestibular stimulation of severely hyperactive mentally retarded children who engaged in perseverative circling and pacing behaviors. These children were the patients of Dr. William Nyhan and were diagnosed as having the Delange syndrome. Given the above outline of the principles underlying stimulus-seeking behaviors and the corresponding presumption of central neural inhibition of sensory impulses associated with that activity, it was felt that sufficiently intense sensory stimulation could "override" the central inhibition of sensory input. Under these conditions, the sensory impulses would be transmitted to the cerebellum and other brain structures and a decrease of the circling-movement stereotypes would be expected. Accordingly, children were placed in an ordinary office chair and whirled as fast as possible. The two children who received less

than two minutes of this intense rotational stimulation were completely quieted and one child yawned and became sleepy. It became clear that stimulant drugs were not necessary to control hyperactivity in these children and suggests that other hyperactive children may also be similarly benefited. It is of interest that one child showed no post-rotatory nystagmus and the other child showed a minimal and very short post-rotatory nystagmus. This finding may reflect neuropathology of vestibular cerebellar mechanisms and other brain structures involved in nystagmus activity in these children. It also suggests that neuropsychological nystagmus assessment in hyperactive children might prove to be diagnostically useful, as it has proven to be elsewhere [63]. This study has been reported previously by Nyhan [64] and indicates the potential of sensory stimulation techniques in the treatment of the sensory-handicapped or sensory-dysfunctional child. These findings are consistent with the theoretical concept of central neural inhibition of sensory input as the mediating mechanism in some movement stereotypes. It is recognized that rigorous and systematic evaluation of this neural-behavioral model is required.

The studies of Mason [65] and Berkson [66, 67] also document that movement stereotypes, and rocking stereotypes in particular, are a consequence of somatosensory-vestibular deprivation. Mason reared isolated infant monkeys on a moving surrogate mother and demonstrated that these animals did not develop rocking behaviors, as did monkeys reared under conditions that were identical except for the fact that the surrogate mother did not move. This study was dramatically illustrated in the film "Rock-A-Bye Baby" [68]. The studies of Berkson reported in this conference and elsewhere [66, 67] indicate that infant monkeys blinded at birth but reared with their mothers and peers do not develop abnormal rocking behaviors. These results support the point of view that visual sensory deprivation alone does not lead to the development of rocking behaviors. This conclusion is also supported by the findings of Adelson and Fraiberg reported in this conference and elsewhere [69, 70] that congenitally blind children do not develop emotional

movement stereotypes provided that they receive sufficient somatosensory stimulation. These findings are also vividly portrayed in the film "Rock-A-Bye Baby" [68]. Riesen [14] has provided additional data that emotional disturbances result from somatosensory deprivation and not from visual deprivation in his studies on the effects of isolation rearing in cats. He states:

"Multisensory deprivation has a much more pronounced effect on the motivational systems of our animals than has the restriction of vision alone. It was not difficult to keep our animals healthy and emotionally capable of learning new behavior if we made sure that they were not deprived in more than the visual sensory area. They were socially dependent upon litter mates and later upon cage mates and human contacts, as mediated tactually and through hearing. A number of animals with which our precautions were insufficient, including both cats and monkeys, were permitted a greater degree of isolation and monotony. These animals proved to be untestable. They were typically either withdrawn or hyperactive to the point of uncontrollability when brought into a complex environment. These observations are not surprising when viewed in relation to the work of the Harlows." (p. 297.)

#### IMMOBILIZATION AS VESTIBULAR AND CUTANEOUS DEPRIVATION

Additional clinical data on the effects of somatosensory deprivation on children have been provided by Freedman [71], and Friedman et al. [72]. They demonstrated that immobilization of infants and children with plaster casts, traction, Dennis-Brown splints, and other restraint procedures resulted in emotional disturbances of depression mixed with hyperactivity and outbursts of violence. Sibinga and Friedman [73] also reported delays in language development in children with a history of immobilization.

Sibinga has also observed gastric ulcerations in children who have been extensively immobilized subsequent to

severe burn injuries or CNS surgery and that a lesser degree of immobilization frequently resulted in chronic idiopathic diarrhea. Sibinga\* has suggested that immobilization or extreme inactivity associated with burn injuries or CNS surgery may be an important contributing factor to the development of Curlin's and Cushing's ulcer. It should be noted that Cushing stressed the importance of nervous influences in the pathogenesis of ulcers and drew attention to the relatively high incidence of acute gastric ulcers after intracranial operations some of which involved cerebellar surgery [74]. In this context the finding by Wolfe [75] that lesions in the posterior vermis of the cat cerebellum produces gastric ulcerations is notable.

Ader [76] has summarized an extensive body of literature that documents the induction of ulcers in rodents by immobilization where the development of acute lesions is related to the degree of restraint and the duration of restraint. Although it is not possible to review, herein, what Ader [76] has already reviewed it seems cogent to mention a few of the more relevant findings from immobilization studies as they relate to somatosensory-cerebellar mechanisms. Specifically:

1. Animals that were immobilized during their activity period developed ulcers whereas animals who were immobilized during their quiescent period of activity did not develop ulcers [p. 17].
2. The degree of ulceration is greater in rats isolated in individual cages than rats who were housed in groups (Martindale, et al., [77]; Essman and Frisone [78]).
3. Differential housing effects were masked by a stress (change in housing conditions) 24 hours prior to immobilization. Incidence of ulcers was increased in the mice that experienced a change in housing (Essman, et al. [79]).
4. Rats who were group housed from weaning until approximately 80 days of age and then subjected

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\*Personal communication.

to 48 hours of immobilization were more susceptible to ulcers than rats housed individually from weaning (Stern, et al. [80]).

5. Prematurely weaned rats (15 days of age) were more susceptible to ulcers than animals weaned at 21 days (Ader, et al. [81]).
6. *Individually-housed* rats who were *handled* for 10 minutes daily for three weeks beginning at weaning (21 days) developed less hemorrhagic damage to the gastrointestinal system than did nonhandled controls when subjected to 48 hours of immobilization at maturity (Weininger, [82]).
7. *Group-housed* rats that had been *handled* 5 or 10 minutes per day were more resistant to gastric lesions than a non-handled group (Winokur, et al., [83]).
8. Rats subjected to *daily handling* throughout the pre-weaning period developed less gastric ulcers than rats subjected to electric shock stimulation after 18 hours of immobilization. This effect held for both group-housed and individually-housed animals (Ader, [84]).
9. Rats subjected to a stress of a shocking cage, and who had entered the "stage of exhaustion from stress" which was characterized by drowsiness, passively rolling on the cage floor, and finally acute rigidity were invariably found to have gastric ulcers (Levrat and Lambert, [85]).
10. Lesions which are experimentally produced in the glandular portion of the rat's stomach are microscopically and histologically indistinguishable regardless of the specific stimulus conditions used to induce the lesion. This suggests that there may be some common pathway or mediating mechanism responsible for the development of such lesions [76] (p. 33).

The above findings leave little doubt that immobilization and isolation procedures (which by definition involve vestibular and cutaneous deprivation) result in gastric ulcerations. The observations that indivi-

dually housed animals are generally more susceptible to gastric lesions than group housed animals (differential somatosensory stimulation) and that *handling* confers a degree of protection from immobilization ulcers provides further evidence of a primary role of somatosensory deprivation induced by immobilization in gastric ulceration. These findings in the context of Wolfe's report that cerebellar lesions result in gastric ulceration provides compelling evidence for a possible cerebellar mediation of immobilization ulcers. Unfortunately, a direct test of this hypothesis has yet to be conducted where cerebellar studies in immobilized animals are clearly indicated.

Relevant to this suggestion are the findings of Eichelman and Thoa [86] that rats immobilized for 2 hours daily over a period of four weeks exhibited elevated levels of shock-induced fighting immediately after immobilization and after four weeks of recovery. Brain tyrosine hydroxylase (the rate-limiting enzyme in the synthesis of norepinephrine-NE) in the hypothalamus was significantly ( $p < 0.01$ ) elevated in both the stressed and recovered groups. Hypothalamic NE was also elevated in pooled samples from the stressed rats when compared with controls. Unfortunately, the cerebellum was not specifically analyzed.

The vestibular-cerebellar hypothesis would also predict that gentle rocking during the immobilization period should act like "handling" in reducing gastric ulcers. Additionally, it is well known that the floccular-nodular lobe of the cerebellum mediates nausea and other symptoms of motion sickness since ablation of that structure prevents the development of motion sickness. The role of the cerebellum in regulating gastrointestinal activity is a supportable hypothesis.

The findings of Schapiro, et al. [87] are related to the above issues. They reported that auditory and vestibular deprivation produced by bilateral labyrinthectomy resulted in a marked inhibition of the acid output and pepsin concentration in canines consequent to insulin hypoglycemia and histamine injections. Although no behavioral studies were carried out they noted that these dogs became friendlier as the study

progressed even though they were individually caged. Unfortunately, no information was given on how much handling these dogs received in the course of this study. It is known that petting and handling reduces irritability and heart rate in dogs [88]. It should also be noted that Schapiro, et al. [87] reported similar gastric secretory responses in canines subjected to bilateral ablation of the eyes and that these effects were not significantly different from bilateral labyrinthectomy. They concluded that "interference with any of the sensory modalities was capable of almost complete suppression of gastric secretion (p. 518). In a review of relevant literature, Schapiro, et al. [87] cited the studies of: (a) Ebstein [89] in which damage to the labyrinths and the internal ear of rabbits resulted in gastric erosions; (b) Le Heux and Kleing [90] in which labyrinth extirpation in cats resulted in a decreased barium transit time; and (c) that deafness in man is associated with diarrhea, constipation and a lack of tone in the intestinal wall. These authors also comment that they have never seen a deaf peptic ulcer patient nor found any literature reports dealing with deaf peptic ulcer patients [87, 91].

Schapiro's et al. study is cited to illustrate that sensory deprivation does have an effect upon gastric function, although evidence for a specific modality effect is lacking in this report. Additionally, the opposite effects between complete sensory deafferentation (bilateral labyrinthectomy and enucleation) and partial functional deafferentation (immobilization) upon gastric function (hypo and hyper gastric activity, respectively) needs clarification. It is beyond the scope of this paper to develop such a clarification, although it can be suggested that bilateral labyrinthectomy which would destroy cells in the floccular-nodular lobe through the mechanism of transneuronal degeneration could mimic, in part, a floccular-nodular lobe ablation, and thus result in a common effect, namely, hypogastric activity. Since the visual system is integrated with vestibular-cerebellar processes, it is natural to raise questions concerning the effect of absence of visual input upon vestibular-cerebellar functioning [92-103].

The recent demonstration of visual afferents into the flocculus of the cerebellum [98, 99], where lesions of the flocculus markedly reduced visual suppression of caloric nystagmus, optokinetic after-nystagmus, positional alcohol nystagmus, and spontaneous nystagmus [104] suggest that nystagmus activity in the blind might be profitably studied. It would also be of interest to determine whether there is altered gastro-intestinal activity and susceptibility to motion sickness in the blind as compared to the sighted. Whether the absence of visual input into the flocculus of the cerebellum would have consequences for any of these functions is not known. It would seem worthwhile to explore the possibility of whether hypogastric activity consequent to enucleation might involve visual floccular-nodular mechanisms. Such studies would have to carefully distinguish between the nodular and floccular structures of the vestibular cerebellum since Cohen and Takemori [104] found that nodulus lesions did not affect visual suppression of nystagmus activity (see Figs. 19 and 22). Dow [100] in his discussion of the Cohen and Takemori study has emphasized the regulatory function of the cerebellum in its links to vision. It is this regulatory function of the cerebellum which is being stressed in this paper and it will be returned to later.

If it is reasonable to assume that immobilization processes adversely affect cerebellar functioning, then it is tempting to speculate whether other symptoms reported to be associated with immobilization might also involve cerebellar mechanisms. Thus, the finding of Sibinga and Friedman [73] reported above that delays in language development were found in children with a history of immobilization naturally raises an inquiry as to the possible role of the cerebellum in language and reading processes. The frequent association of hyperactivity syndromes with learning, reading, and language disorders lends support to this line of speculation. It is hardly necessary to point out that speech and language are highly developed motor skills requiring exquisite control and regulation

of motor sequences. Needless to say, regulation of motor sequences is one of the primary functions of the cerebellum. The suggestion that the cerebellum may be involved in language and reading processes and in their disorders is consistent with theoretical models of the cerebellum developed by Marr [105]; Blomfield and Marr [106] and Albus [107, 108] to account for memory processes and the perception of patterns. Based upon the known anatomy and physiology of the cerebellum, Albus [107, 108] has postulated that the cerebellum is structurally and functionally equivalent to a modification of the classical perception pattern-classification device. He has suggested that "the mossy-fiber granule cell Golgi cell input network performs an expansion recording that enhances the pattern-discrimination capacity and learning speed of the cerebellar Purkinje response cells" (p. 25). He has further suggested that the parallel fiber synapses of the dendritic spines of Purkinje cells, basket cells, and stellate cells are all specifically variable in response to climbing fiber activity and that variability is the mechanism of pattern storage. Albus also argues that in order for the learning process to be stable, pattern storage must be accomplished principally by weakening synaptic weights rather than by strengthening them. It is recognized that the suggestion that the cerebellum may be involved in language and reading processes requires rigorous evaluation and that the data to support this hypothesis is tenuous and unsatisfactory. Although a more detailed outline of cerebellar anatomy and function is presented later, it should be noted that the only two neural inputs into the cerebellum are the climbing fiber, and mossy fiber systems and that the only output from cerebellar *cortex* is the Purkinje axon system which is exclusively inhibitory in function. The only other output from the cerebellum. . . the deep nuclei. . . is exclusively excitatory in function.

The above studies suggest that the problems of the blind are not necessarily confined to the visual sensory system and that many problems of the visually deprived may well involve concomitant somatosensory deprivation and associated vestibular-

cerebellar mechanisms. For example, Fraiberg\* has noted that it is not infrequent for blind infants to sleep or remain untouched and unhandled for as much as 14 to 18 hours per day. It is not surprising that special efforts must be made to stimulate the other sensory systems, particularly the somatosensory system in blind infants and children.

It would be remiss not to mention in this section on immobilization the findings of Zubek et al. [110] who immobilized adult faculty subjects for periods up to 24 hours (mean = 12.9 hours; S.D. = 6.6 hours). Only 8 of their 40 subjects were able to endure immobilization for the prescribed 24 hours. Vision and hearing was not interfered with and social interaction with the experimentors was maintained. Head movements were prevented with a head-holder. These investigators reported that 85 percent found immobilization stressful and that 75 percent stated they would not repeat the experience in a week's time. The severe restriction of a kinesthetic (proprioceptive and vestibular) activity *alone* resulted in their showing more "intellectual inefficiency, bizarre thoughts, exaggerated emotional reactions, time distortions, changes in body image, unusual bodily sensations and various physical discomforts, than did the recumbent controls" (p. 128). Specifically, subjects felt "that some part of their body was disconnected or did not belong to the rest of the body, that they were melting or merging into their surroundings, and that at times they felt like a different person." (p. 126). Reports included "whole body floating or revolving in space, arms or legs rising, whole body feels as heavy 'as a ton of bricks'; and various distortions of body properties such as one limb being much shorter than another" (p. 126). Psychosomatic complaints were also frequent and included "periodic aches and pains, numbness, *dizziness*, physical discomfort, chills, perspiration, weakness, strong desire to scratch parts of the body and difficulty in sleeping. These physical symptoms, together with the emotional changes reported earlier, were responsible for almost all of the early terminations of the experiments prior to the prescribed

\*Personal communication.

24 hours" (pp. 126-7). Additional data are summarized elsewhere [111, 112].

It is apparent from the above that severe somatosensory deprivation in *adults* for less than an average of 13 continuous hours has profound effects upon the integrity of intellectual, emotional, and somatic functions. Disintegration of integrative functioning would seem to aptly describe the above effects of somatosensory deprivation. It would seem appropriate to inquire as to the effects of "insufficient" somatosensory stimulation during critical periods of development, particularly upon maturation of integrative functioning. What constitutes "sufficient" or "insufficient" somatosensory stimulation for the developing infant appears to be an issue of extraordinary importance and major research efforts should be directed to that question.

## SENSORY SUBSTITUTION

The use of alternate sensory systems, particularly, the somatosensory, in developing "visual perceptions" in the blind is described by Bach-y-Rita in this publication. An important element in the ability of the blind to perceive objects from pattern stimulation of the skin is the subject's control of the video camera which provides the image that is converted to tactile stimuli. Thus, somatosensory, specifically, proprioceptive cues become critical in "tactile-visual" perceptions, particularly when these "perceptions" are externalized in space and not referenced to the specific skin surface being stimulated and where "transfer" of these perceptions occur, i.e., it makes little difference (within limits) what skin surface is stimulated. Bach-y-Rita elaborates on these issues in his paper here and elsewhere [113]. These observations assume greater significance in the context of the findings of Held and Hein [114]; Hein and Held [115]; Held [116, 117], and Held and Bauer [118]. These investigators have provided strong support for the role of motor functions in perception. For example, animals reared under conditions which deprived them of visual information of limb movement were characterized by defects in visually guided behavior. Similar

defects were also found when animals were passively moved around in an environment that would otherwise permit the development of normal vision. Thus, the relative role of *active movement* versus *passive movement* becomes critical in certain issues of visual perception. It is of more than passing interest that the role of movement in the "tactile-visual" perception of the blind is as relevant for them as it is for the "normally" sighted.

Given the above it seems natural to speculate on the possible role of the cerebellum in sensory substitution phenomena. Snider [101, 119] has reviewed the role of the cerebellum in regulating afferent input and Cangiano, et al. [120] have shown that the excitability of the fast conducting cutaneous afferents can be increased by 180 to 200 percent when the contralateral fastigial nucleus in the cat cerebellum is repetitively stimulated. It is beyond the scope of this paper to further elaborate on the neural mechanisms of sensory substitution and these issues have been treated elsewhere (Bach-y-Rita [113]; Sterling, et al. [121]).

Additional evidence that somatosensory experiences are crucial for the blind infant has been provided by Adelson and Fraiberg in this publication where they report that *delays* in mobility and locomotion in the blind infant could be decreased when auditory-*tactile* hand experiences were provided so that sound alone could serve as an effective cue for forward progression. This becomes particularly important since these authors also point out that sound does not begin to function as a cue to the presence of an out-of-reach object until late in the first year. Given this limitation of auditory cues it would seem desirable to utilize more extensively somatosensory cues and olfactory cues in the localization of objects in space. Thus, different objects could have different "smells" (perfume, spices, etc.) to facilitate the blind child's localization of the objects in space. Since visual and auditory sensory functions are developed later than other sensory functions [122, 123] it would seem possible to train the blind infant in spatial-temporal perceptions much earlier with additional sensory cues

rather than with auditory cues alone. The combination of olfactory, somatosensory (tactile and vestibular) with auditory cues might facilitate the development of intrasensory organization and functions in the blind.

It should be emphasized that the blind infant's inability to reach out to some stimulus object is not just a consequence of being unable to see the object. Helbrugge's study, illustrated in the film "Rock-A-Bye Baby," demonstrated that a sighted institutionalized child could not reach out and localize a rattle at six months of age. This child did not smile or show any signs of positive affect. This was corrected after a one-to-one maternal caretaker relationship was established. It was also notable that the lack of emotional expression of infants playing and responding to objects in Selma Fraiberg's film was associated with a failure to localize objects in space at 10 months of age. At 11 months of age the child crawled across the room and *smiled* when he retrieved the object. It is possible that the "smiling" response associated with object retrieval in these infants might reflect a behavioral sign of "meaning acquisition." Whatever the preferred interpretation for these events, it should be recognized that affective-emotional and psychomotor processes (somatosensory functioning) play an all-important role in intellectual-cognitive development of all infants and that cognition is pleasurable [124].

In this context it is relevant to emphasize the findings of Adleson and Fraiberg in this report and elsewhere [69, 70] that *postural* test items which reflect neuromuscular maturation in control of head and trunk are not significantly different between the blind and sighted but that *mobility* items which normally follow each postural achievement were considerably *delayed* in the blind. It was also noted that the onset of self-initiated mobility was related to the child's ability to reach out and attain an object presented by sound cue alone. This phenomenon does not occur until the last quarter of the first year. It should also be noted that the cerebellum has a major role in the *initiation* of movement [125, 126].

## INSTITUTIONALIZATION AS SENSORY DEPRIVATION

It would seem helpful, however, to pursue further other factors that contribute to psychomotor retardation. The findings of Helbrugge in "Rock-A-Bye Baby" have been cited previously. It is well established that institutionalization and orphanage rearing of *sighted* children results in low developmental quotients and delays in the appearance of locomotor abilities [3, 4; 6, 7; 127-136]. It is particularly relevant to note the rearing conditions in the Paraskevopoulos and Hunt [132] study which included:

- a. an orphanage with an infant-caretaker ratio of 10:1,
- b. an orphanage with an infant-caretaker ratio of 3:1, and
- c. traditional home family rearing.

Marked and significant differences in development were obtained between these groups with the greater deficits occurring in the infant-caretaker ratio of 10:1. Substantial differences in somatosensory stimulation (touching, holding, and carrying) may have characterized these groups.

Unfortunately, quantitative data on the extent and duration of specific forms of sensory stimulation are lacking in this study and in most studies of this kind. It is usually presumed that a lower infant-caretaker ratio will result in increased physical contact and handling between infants and caretakers. This assumption, however, is not always warranted and systematic quantitative data on the specific nature of sensory stimulation should be a requisite for future studies of this kind.

Dennis [136] describes the profound deprivation of sensory stimulation in his study, *Children of the Creche*. He noted that "babies from birth to about one year spent most of their time in bassinets (Fig. 19). During most of this year they were fed by bottle in their cribs, and were almost never taken from their cribs except for daily bathing and change of clothing" (p. 13). In addition there was profound cognitive (visual and auditory) deprivation.

The infant-caretaker ratio was about 10:1 and most of the caretakers had themselves been reared in the Creche as foundlings during their first six years. The mean caretaker IQ was 57. Dennis [136] also described the paucity of language where there was little verbal communication between child and caretaker and virtually none between the children. *Children of the Creche* must be read to appreciate the degree of experiential deprivation imposed upon the infants and children. Dennis [136] summarizes: "It seems correct to say that there was no respect in which the experiences, either sensory or motor, of the Creche foundlings were equal to those of even the poorest family-reared child in Beirut" (p. 23).

The consequences of the above deprivation were severe, e.g., no foundling under one year of age could sit alone, or creep, or scoot and at two years of age many could not walk. At one year of age both boys and girls had a mean behavioral quotient of about 50 which they retained as long as they remained in the Creche. Legalization of adoption permitted them to assess the effects of a foster home upon development. They reported that Creche foundlings adopted *within* the first two years of life attained an IQ of approximately 100 at age four. Children who were adopted after the age of two showed increases in their test scores but retained the absolute deficiency in mental age which they had when they left the Creche. Dennis [136] concludes that intervention before two years can reverse environmental retardation whereas intervention after two years does not reverse the impairment which he considers to be relatively permanent. Specifically, "those adopted between ages 1-0 and 1-11 had gained more in IQ in approximately two and one half years than those adopted one year later had gained in almost seven years" (p. 90). He suggested that age two may be a critical period for complete recovery from the effects of experiential deprivation upon intelligence.

It is of interest that Geber [137] found that African infants appear to lose their accelerated developmental standing if they continue to be raised in the traditional environment after two years and Masse's [109] summary also indicates that

precocity disappears by age two, as reported by Warren [138].

The effects of deprivation in *The Creche*, however, were not confined to intelligence. Dennis [136] states: "While the test scores have received the greatest emphasis in this report, the data, fewer in quantity, on school progress, social, marital, and vocational adjustment, and psychiatric referrals are probably of equal importance. It has been shown that the two kinds of data are closely related. Those who were in experientially deprived institutions throughout childhood were not only of low intelligence but also evinced more signs of social maladjustment and personality disorder than did the adoptees" (p. 107).

Although it is clear from Dennis' description of experiential deprivation that multiple sensory deprivation was involved, attention must be given to the profound somatosensory deprivation that the *Children of the Creche* experienced. It would be of interest to determine whether modern techniques in quantitative electrophysiology, specifically, nystagmus and assessment of brain hemispheric relationships utilizing cortical evoked potentials obtained from the different sensory modalities might not provide discriminative information on the relative impairment of the different sensory systems. Such a follow-up study would be invaluable for developmental theory and rehabilitation practices.

This writer is intrigued by the two-year critical period which Dennis' data appears to identify and it would seem heuristic to inquire whether this could be supported by a parallel critical period in brain development. The observation made later in this paper that postnatal neuronal development of the human cerebellum continues to about two years of age is suggestive of one possibility. It would seem timely to explore in some systematic manner the occurrence of behavioral developmental landmarks with landmarks of brain structure development and function as they may relate to the differential rates of sensory modality development.

## PRECOCIOUS MOTOR DEVELOPMENT

Additional evidence that may be interpreted as supporting the singular importance of somatosensory deprivation in contributing to developmental deficits is the study of Geber [137] who reported precocious motor development in African infants when contrasted to caucasian infants. The observation that precocity is greater for infants from traditional or lower class families than for westernized or middle class families suggests that social factors need to be considered in accounting for this precocity [133, 134; 137]. In a recent study on African infant precocity, Leiderman, et al. [134] found that Kikuya infants surpassed United States test performance on 38 mental test items and 20 motor test items. The Kikuya lagged behind U.S. test performance on 7 mental test items and 2 motor test items.

In suggesting reasons for these differences, Leiderman, et al. [134] stated:

"It should also be noted, however, that maternal caretaking within the Kikuya community involves more *physical contact* with the infant in the first six months of life, and therefore might also account for these differences (additional data on maternal behavior will be presented elsewhere)." (*Italics mine*, p. 248.)

Additionally, in a multiple regression analysis of Bayley test scores with demographic factors, the number of individuals over 40 years of age in the household was the only factor significantly correlating with motor test scores [134]. This suggests that additional infant caretaking (greater somatosensory stimulation) may have been provided by those over 40 years of age which would have contributed to infant motor development which is consistent with the greater maternal-infant physical contact observed in the Kikuya by the authors. This interpretation is further strengthened by their findings that infants from a household with two or more individuals aged 41-60 scored *highest* on motor test scores compared to those

infants from households which had no adults over the age of 41 years. Infants from households without adults over age 40 scored lowest on motor test scores. It is apparent that the hypothesis that adults over 40 years of age provide additional somatosensory stimulation to the infant can only be resolved by direct observation.

Warren [138], recently reviewed a number of studies on African infant precocity and concluded that it has not been satisfactorily demonstrated. There is some basis, however, to question his conclusion. Warren [138] reviewed 14 studies in which 12 supported precocity and two did not. Most of the studies were rejected because of flaws of design, analysis, and reporting. The studies of Kilbride, et al. [139], Theunissen [140], Falmagne [141], and Liddicoat and Koza [142] were considered satisfactory. The studies of Theunissen and Falmagne found no general differences between blacks and whites and the studies of Kilbride, et al. and Liddicoat and Koza found evidence in support of African infant precocity. It should be noted that in no instance did any study report white infant precocity. It is evident that Warren [138] gives greater weight to the studies of Theunissen and Falmagne than to the studies of Kilbride, et al. and Liddicoat and Koza.

Warren [138], however, has made the following observation:

"The new Bayley test, however, has been very carefully standardized and the most compelling evidence for African precocity based on comparison with test norms comes, therefore, from Kilbride and Goldberg, using the motor scale only and from Lusk and Lewis [143] who used both scales but with only 10 subjects of various ages. The real problem of course, relevant to all research except that of Theunissen and Falmagne, is that comparisons were made only with available Western norms and not with samples of European babies taken by the same investigator. A further point that may be important is that most of those who report African precocity

against norms made observations in the infants' own homes and then compared performance with normative data collected in clinic situations" (p. 360).

With respect to differences by social level, however, Warren [138] states: "For once, the results, sparse as they are, show consistency. Infants from homes of a low social level are initially more advanced than elite babies" (p. 363). He concludes: "It can hardly be claimed that we have here a definite phenomena. However, there is a somewhat surprising indication that infants from poor African homes develop more rapidly at first than those from elite homes" (p. 364).

It is the interpretation of this writer and others that this social class effect may well be due to the westernization of child rearing practices in the higher social classes. The lower social class maintains ethnic customs that involve greater physical handling and carrying of the infant. As Lusk and Lewis [143] comment: "Infants of acculturated families tended to be kept in cribs much of the time. . . they were held and carried much less often than the village infants and fed on schedule rather than on demand" (p. 59). Thus, African social class differences in infant development may well be directly a function of variation in early sensory stimulation, specifically somatosensory stimulation. This hypothesis, however, requires rigorous evaluation.

Warren [138], in discussing these issues stated:

"The clear prima facie reason for expecting uniform African development is a racial-genetic hypothesis. . . . No other hypothesis would plausibly suggest uniform African development across the continent. Uniformity of infant environments is too much to ask" (p. 364).

This writer would like to suggest that this above conclusion by Warren needs clarification. Specifically, this writer has evolved a somatosensory theory of development which predicts that cultures characterized by high infant physical

affection (higher body touching, contact and carrying) would be characterized by low physical violence, and conversely that cultures characterized by low infant physical affection (low body touching, contact, and carrying) would be characterized by high physical violence. This relationship was verified by consulting Textor [144] which summarizes a wealth of cross-cultural data. It was found that the coded scale of *Infant Physical Affection* developed by Barry, Bacan, and Child was significantly related to the coded scale of "Killing, Torturing or Mutilating the Enemy" developed by Slater and described in Textor [144]. This relationship was significant at the  $p = 0.004$  level which correctly classified 36 of the 49 cultures in the sample. These results are summarized in Table 10 below.

The Barry, Bacon and Child scale included the following items, rated from 1 to 7:

"Display of affection toward the infant: to what extent is he held, fondled, caressed, played with?" ([145], p. 293).

This writer analyzed a more recent coded scale on infant physical contact developed by Barry and Paxson [146] which was also found to be significantly related to Slater's coded scale of physical violence ( $p = 0.03$ ,  $N = 43$ ). The Barry and Paxson scale was defined as follows:

#### "Bodily Contact:

This measures the proportion of the day when the baby is held or carried by any caretakers. Two stages, an early period; a later infancy are defined as (a) the first few months after birth; and (b) when the baby first crawls, at approximately nine months of age.

1. Limited to routine and precautionary care
2. Only occasionally
3. Up to half of the time
4. More than half of the time
5. Almost constantly."

In brief, there is evidence of systematic relationships between specific infant environments and later adult behavioral characteristics.

TABLE 10

## Infant Physical Affection/Adult Physical Violence

| High Infant<br>Physical Affection<br>Low Adult<br>Physical Violence | Low Infant<br>Physical Affection<br>High Adult<br>Physical Violence | High Infant<br>Physical Affection<br>High Adult<br>Physical Violence | Low Infant<br>Physical Affection<br>Low Adult<br>Physical Violence |
|---------------------------------------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------|
| Andamanese                                                          | Alorese                                                             | Cheyenne                                                             | Ainu                                                               |
| Arapesh                                                             | Aranda                                                              | Chir-Apache                                                          | Ganda                                                              |
| Balinese                                                            | Araucanians                                                         | Crow                                                                 | Kwakiutl                                                           |
| Chagga                                                              | Ashanti                                                             | Jivaro                                                               | Lepcha                                                             |
| Chenchu                                                             | Aymara                                                              | Kurtatchi                                                            | Pukapuka                                                           |
| Chuckchee                                                           | Azande                                                              | Zuni                                                                 | Samoans                                                            |
| Cuna                                                                | Comanche                                                            |                                                                      | Tanala                                                             |
| Hano                                                                | Fon                                                                 |                                                                      |                                                                    |
| Lau                                                                 | Kaska                                                               |                                                                      |                                                                    |
| Lesu                                                                | Marquesans                                                          |                                                                      |                                                                    |
| Maori                                                               | Masai                                                               |                                                                      |                                                                    |
| Murngin                                                             | Navaho                                                              |                                                                      |                                                                    |
| Nuer                                                                | Ojibwa                                                              |                                                                      |                                                                    |
| Papago                                                              | Thonga                                                              |                                                                      |                                                                    |
| Siriono                                                             |                                                                     |                                                                      |                                                                    |
| Tallensi                                                            |                                                                     |                                                                      |                                                                    |
| Tikopia                                                             |                                                                     |                                                                      |                                                                    |
| Timbira                                                             |                                                                     |                                                                      |                                                                    |
| Trobriand                                                           |                                                                     |                                                                      |                                                                    |
| Wogeo                                                               |                                                                     |                                                                      |                                                                    |
| Woleaians                                                           |                                                                     |                                                                      |                                                                    |
| Yahgan                                                              |                                                                     |                                                                      |                                                                    |

N = 49  
XSQ = 8.38  
P = 0.004

PHI = 0.41  
% = 73

## THE GUATEMALAN STUDY

The above cross-cultural data has direct relevance to a study reported by Kagan and Klein [147] on early infant development in remote villages of Guatemala. In their comparative study of infant cognitive development they found that "the rural Guatemalan infants were retarded with respect to activation of hypotheses, alertness, and onset of stranger anxiety and object permanence, (however) the preadolescents' performance on the tests of perceptual analysis, perceptual inference, and recall and recognition memory were comparable to American middle-class norms" (p. 957). These authors conclude that "Infant retardation seems to be partially reversible and cognitive development

during the early years more resilient than had been supposed" (p. 957). This concept of "resiliency" or "recovery of function" has significant implications for social policies that attempt to correct the adverse consequences of "impoverished" environments upon human development. For example, "these data, together with the poor predictive relation between scores on infant developmental tests and later assessments of intellectual functioning, strengthen the conclusion that environmentally produced retardation during the first year or two of life appears to be reversible" (p. 959). And, "If the first (early) environment does not permit the full actualization of psychological competencies, the child will function below his ability as long as he remains in that

context. But if he is transferred to an environment that presents greater variety and requires more accommodations, he seems more capable of exploiting that experience and repairing the damage wrought by the first environment than some theorists have implied" (p. 960).

Although not intended by the authors the above statements could be readily interpreted by social planners that the early environment is not all that important for human development and that, therefore, major environmental enrichment programs for "poor" infants and children are not really necessary. For these reasons serious attention must be given to the Kagan and Klein study, particularly with respect to a) whether early *cognitive* deficits have actually been satisfactorily demonstrated during infancy; b) what actually has been "reversed" to support the concept of "resiliency" and "recovery of functions"; c) the criterion of "average" performance: mediocrity vs. superior performance, i.e. excellence of achievement; and d) whether the tests employed at the developmental age of final testing (11-12 years) would permit the assessment of the effects of these early environments upon "ultimate" development, i.e. "excellence" of achievement. This is to suggest that average or mediocre functioning may not be affected by certain early deprivation but superior functioning may be seriously affected.

The beginnings of this particular study by Kagan and Klein was influenced by their observations of Guatemalan infants and children:

"During the first 10-12 months, the San Marcos infant spends most of his life in the small, dark interior of his windowless hut. . . . The infant is rarely spoken to or played with, and the only available objects for play, besides his own clothing or his mother's body, are oranges, ears of corn, and pieces of wood or clay. These infants are distinguished from American infants of the same age by their extreme motoric passivity, fearfulness, minimal smiling, and, above all, extraordinary quietness. A few with pale cheeks and vacant stares had the quality of tiny ghosts and resembled the description of the

institutionalized infants that Spitz called marasmic. Many would not orient to a taped source of speech, not smile or babble to vocal overtures, and hesitated over a minute before reaching for an attractive toy" (pp. 949-950).

"We saw listless, silent, apathetic infants; passive, quiet, timid 3-year-olds; but active, gay, intellectually competent 11-year-olds. Since there is no reason to believe that living conditions in this village have changed during the last century, it is likely that the alert 11-year-olds were, a decade earlier, listless, vacant-staring infants. That observation has forced us to question the strong form of continuity assumption in a serious way" (pp. 947-948).

The above clinical description of Guatemalan infants, which categorizes them as similar to Spitz's institutionalized infants, carries with it all the developmental implications that are known about institutionalized children. It is well established that extreme emotional disturbances occur in children deprived of human physical contact (hospitalization and institutionalization) and that these emotional disturbances are intimately linked to poor intellectual development. Kagan and Klein assumed that similar behaviors warranted the postulating of similar etiologies and developmental outcomes. However, in their own report they cite evidence that cannot support their equating of Guatemalan infants with Spitzian institutionalized infants:

"The infants cried very little because the slightest irritability led the mother to nurse her child at once. Nursing was the single, universal therapeutic treatment for all infant distress, be it caused by fear, cold, hunger, or cramps" (p. 950).

Clearly, the maternal closeness and prompt and rich physical affection given the Guatemalan infant by its mother precludes any comparison with Spitz's maternally-socially deprived infants. Thus, the observations of "fearfulness," "minimal smiling" and "extraordinary quietness" must be accounted for differently

and interpreted differently. It is suggested that Kagan and Klein committed the classical error of interpreting a natural cultural difference in emotional expressivity (Guatemalan vs. American) as evidence for a "deficit" on part of the non-American culture. American infants are expected to be smiling, extroverted, assertive and reactive to their environment. Guatemalan infants are somber, introverted, quiet and relatively non-reactive to their environment. The interpretation of the Guatemalan infant behaviors as "marasmic," i.e. as abnormal appears to be a major diagnostic error. This has led to an interpretation of task performance differences as reflecting deficits in cognitive abilities when it is more likely that such differences can be attributed to emotional and motivational factors.

The lack of familiarity with complex visual and auditory stimuli from "western" culture tests and "the unstimulating environment of the dirt hut" are more likely explanatory mechanisms than the mechanisms of "maternal-social" deprivation associated with institutionalization. Consequently, questions can be raised as to the precise nature of the "retardation" observed. If novelty and fear reactions and "motivational" variables are contributing sources of variance to "retardation" then questions must also be raised as to which "functions" have been "recovered." Recall that the San Marcos infants were characterized by their "extreme motoric passivity, *fearfulness*, *minimal smiling*, and above all, extraordinary quietness. . . . Many would not orient to a taped source of speech, *not smile* or babble to vocal overtures and *hesitated over a minute* before reaching for an attractive toy" (italics mine) (pp. 949-950). Additionally, the close presence of white strangers who smile a lot and speak a strange language could be expected to enhance their "fearfulness" in a test situation. Body language differences would appear to be substantial with unpredictable consequences upon child behavior. Unfortunately systematic data on the emotional state of children during testing was not recorded. It could be argued that it was the emotional-motivational "deficits" that were overcome ("recovered") with increasing

experience of a novel environment rather than cognitive deficits per se. The phenomena described by Kagan and Klein [147] are more reminiscent of Fuller's [149] description of "emergence shock" in dogs required to confront a novel complex multi-sensory stimulating environment after a period of rearing in a sensorily restricted environment. Similarly, Harlow described the necessity of testing his isolation reared monkeys "in isolation" if the learning capabilities of the animals were to be assessed. It was found that testing these animals in a novel social environment was so emotionally disruptive as to prevent the assessment of learning; and that enriched monkeys tested in the home-cage environment performed significantly better than enriched monkeys tested in novel-cage environment (Gluck, et al., [150]).

In this context it is not unreasonable to suggest that San Marcos children who typically spend most of their day within a 500 yard radius of their homes and who are taken with their mother to a "special laboratory equipped with a chair and a stage that simulated the setting in the Harvard laboratories" might experience some negative emotional states that could interfere with "cognitive performance." This point of view receives some support from their finding that on a test of recall memory for familiar objects common to village life (animals, kitchen utensils, clothing) no significant differences were found between Guatemalan and American children for both age groups (7 and 11 year olds), whereas tests with strange materials (Harvard Test Apparatus) yielded significant differences.

Kagan and Klein's [147] interpretation of Harlow's data that isolation reared monkeys "could, if the experimenter were patient, solve the complex learning problems normally administered to feral-born monkeys," (p. 959) erroneously leaves the impression that isolation rearing has no lasting effects upon cognitive functioning and/or that appropriate environmental intervention can fully reverse any deficits observed: "The prolonged isolation did not destroy their cognitive competence (Harlow, Schiltz and Harlow, 1969 [151]," [147] p. 959). On the contrary,

Harlow, et al [152] reported that "socially enriched preadolescents and adolescents, as contrasted with the socially isolated adolescents and controls, proved to be superior at the 0.001 significance level on our most complex problem--oddy-learning set" (p. 543). Additionally, Gluck, et al. [150] reported that "monkeys reared in enriched environments were superior to partially isolated controls on the complex oddity-tasks but not on two-choice discriminative or delayed response problems" (p. 598). The partial isolates stabilized at approximately 65 percent correct responding whereas the enriched animals stabilized at approximately 80 percent correct responding. These authors conclude:

"We have suggested elsewhere (Gluck and Harlow, 1971 [153]; Harlow et al., 1971 [152]) that differential rearing has effects on learning performance only indirectly, by either adversely affecting adaptation of deprived subjects to the testing procedures, thus biasing their test scores in a negative direction, or by providing enriched subjects with specific learning experiences which transfer to the criterion test. The present data force a significant change in stance with regard to this position.

First, prior to the presentation of any problems, all present subjects were tediously adapted to all facets of the testing procedure according to rigid criteria. This insured that no pretest group performance differences existed to confound that which followed. Second, since the enriched monkeys demonstrated learning superiority only on the oddity tasks and not generally across all tests, the specific transfer hypothesis does not presently seem tenable. The identification of the nature of these observed differences is left as the problem for future research." --([150] p. 603)

Further, Davenport and Rogers [154-156] found significant differences between deprived and feral reared chimpanzees on two-choice discriminations and delayed-response tasks as well as oddity problems.

Davenport, et al. [157] tested six adult chimpanzees that had been reared for the first two years of life in restricted laboratory environments and were found to be significantly inferior in cognitive skills to eight wild born control subjects, as assessed by *Transfer Index* testing. These authors concluded:

"The persistence of cognitive deficits in the restrictedly reared chimpanzees, even after 12 years of environmental enrichment, prolonged testing, and group maintenance, is interpreted to mean that deficits so incurred are not readily corrected, at least in the chimpanzee. . . . These results, in conjunction with those reported recently by Harlow, et al. (1971 [152]) with rhesus subjects, also should serve to reinforce the concerns of those who believe that long-term, perhaps life-long cognitive deficits may be induced in human children who do not have the benefit of enriched, stimulating experiences during infancy and the preschool years" (pp. 346-47).

The above data strongly question the "resiliency and recovery of function" of the San Marcos children, as suggested by Kagan and Klein [147]. This could be due to several factors:

- a. insufficient cognitive task complexity at age 11 years (assuming a cognitive deficit exists);
- b. cognitive differences obtained at earlier ages could be attributable to confounding emotional/motivational variables and not to any real cognitive deficit per se;
- c. lack of cognitive differences at later ages (11-12 years) may reflect:
  1. increasing familiarity with a complex and changing environment with concomitant reduction in emotional/motivational variables which interfered with earlier cognitive task performance; and
  2. the absence of a presumed absolute infant retardation

in the first place since the above animal studies do show lasting cognitive deficits consequent to an early impoverished environment.

It should be pointed out that the chimpanzee data are probably more relevant to human infant data since the chimpanzee is closer phylogenetically to man than the monkey. This is reflected in the prolonged period of infant helplessness in the chimpanzee and man when compared to the monkey. Issue must also be taken with Kagan and Klein's [147] interpretation of the "monkey therapy" studies of Suomi and Harlow [160, 161] which are reviewed later in this paper. Briefly, the "monkey therapies" are effective when initiated during *infancy* and involve *primarily physical contact* variables. Therapies initiated later in life and which do not involve physical contact have not reversed the social and emotional abnormalities [158-162]. Since the San Marcos infants were never deprived of physical contact (in fact they received an enriched amount of physical contact), it is difficult to appreciate the relevance of these animal studies to the Guatemalan infant environment and the assumption that the San Marcos infants were deprived in the Spitz and Harlow sense. Both short-term and long-term effects of partial and total social isolation are well described [163-169; 285, 286] and these studies also question the "recovery of function" thesis of Kagan and Klein [147]. It is recognized however, that the San Marcos infants had a restricted visual and auditory environment in contrast to infants from a western culture. This lack of experience with a highly stimulating, complex and ever-changing environment that infants from a western culture experience throughout the early developmental years undoubtedly contributed to their passivity, quietness, and introverted personality characteristics. It is apparent that terminology such as "vacant stare," "tiny ghosts," "institutionalized infants," and "marasmic" denote a different psychological condition than that denoted by such terms as "passivity" and "quietness." Perhaps it is not too extreme to suggest that Kagan and Klein committed a cultural error by judging the behavior of another culture (passive, quiet, contemplative,

introverted) in terms of the behavior of one's own culture (aggressive, active, highly verbal, extroverted). It is questionable whether behaviors of western cultures are more desirable, let alone "superior" to the behaviors of non-western cultures. For example, the excessive emphasis upon "cognitive" functioning to the neglect of "emotional/affective" functioning in western cultures is a case in point and it appears that this cultural bias has influenced the Guatemalan study, as reported by Kagan and Klein [147].

The recent findings of Epstein [170, 171] are particularly relevant here since he demonstrated that humans exhibit growth spurts in brain weight and skull circumference around the ages of 7, 11, and 15 years; and mind growth spurts during the intervals 2-4; 6-8; 10-12; and 14-16 years. He has some evidence that spurts in learning capacity exist and that these correlate with the brain-mind growth spurts. Further, Gottlieb, et al. [172] in their reviews of a variety of animal deprivation studies conclude that if animals are deprived through the final or second brain growth spurts they may not have a normal final brain growth spurt. They extend these findings to the human condition and conclude that if a child is deprived during one or all of the first three brain/mind growth spurts that this would result in an abnormal final brain/mind growth spurt. The implications for human development are enormous since, as Epstein and his co-workers point out, the final brain growth spurt may be correlated with abstract or conceptual thinking. The characteristic concrete-bound or non-abstractive thinking of deprived children was cited as supportive of this interpretation (Jensen, [173]). The implications of the above for the Guatemalan study [147] are self-evident. The oldest children tested by Kagan and Klein were 11-12 years, i.e. during the third brain/mind growth period. It would be necessary to test these children at 17 years of age with sufficiently complex tasks (comparable to the oddity tasks which were failed by deprived monkeys and chimpanzees) to determine the validity of the Kagan/Klein hypothesis.

Significant differences between the experimental and control groups at age 17 would essentially nullify the "recovery" arguments advanced by Kagan and Klein and would provide evidence in support of Epstein's hypothesis that early deprivations during the first three brain/mind growth periods affects the development of the final brain/mind growth spurt which is associated with higher complex cognitive functioning. Failure to find differences would raise questions about the nature of the early "deprivations" and leave unresolved the issue of "recovery." Clearly, the retesting of the Kagan-Klein sample at age 17 should be a high priority objective. The utilization of quantitative electrophysiological assessments *during* cognitive task performance would contribute invaluable information upon brain-behavior functions as they relate to the Kagan-Klein and Epstein hypotheses.

In summary, if emotional and motivational factors have contributed to deficiencies in cognitive performance during earlier testing of the San Marcos children, then the assumption of "cognitive retardation" must be questioned as well as "cognitive recovery." Otherwise the implication (not intended by the authors) that early deficits can be overcome without intervention could be extrapolated to justify a national social policy previously suggested by a "benign neglect" doctrine. It hardly needs to be emphasized that cognitive *excellence* in contrast to cognitive *mediocrity* is highly unlikely to be realized from a Guatemalan village environment nor from many American urban environments as we know them.

Additionally, emotional and affective excellence is as important as cognitive excellence for they continually interact throughout development, and in the final analysis, cognitive behavior cannot be fully understood in the absence of knowledge of its affective components.

## COGNITIVE-AFFECTIVE INTERACTIONS

The interplay between "cognitive" and "affective" processes can be approached by focusing upon the sensory modalities involved in their functioning as the following study by Pedersen,

Yarrow and Rubenstein [174, 175] illustrates: they examined mother-infant interactions in terms of the sensory modality used for communication. These "sensory-interactions" were related to scores of mental and psychomotor development which were obtained from the Bayley Scales of Infant Development plus four additional measures derived from the Bayley, namely:

- a. social responsiveness;
- b. goal orientation;
- c. secondary circular reactions (perseverative play); and
- d. object permanence.

The results indicated that *kines-thetic* stimulation was the most important sensory modality variable since it was significantly correlated with all six dependent variables where three of these six correlations were significant at the one-percent level. Thus, vestibular stimulations (physical holding and carrying) were significantly related to the infant's mental and psychomotor developmental status as well as to the specific social and cognitive-motivational variables. Particularly interesting was the finding that passive and active somesthetic (tactile) stimulation were significantly related to only two of the dependent variables, viz., *goal orientation* and *secondary circular reaction*. Strikingly, visual and auditory stimulation were significantly related to only one dependent variable, viz., *social responsiveness*.

The above study clearly supports the prepotency of somatosensory stimulation, particularly vestibular stimulation, in infant development and provides additional evidence for the primacy of the near receptors over the distance receptors for *infant* motor-mental and emotional-social development [35, 36; 57; 134; 174, 175]. The distance receptors assume increased significance in later development. The above data assumes greater significance for Adelson and Fraiberg's study where they noted that "*physical intimacy* united with the sound of the parent's voice provided the first union of tactile-auditory experience for the children" which influenced the delays in mobility and locomotion (*italics mine*). The findings of

Casler [135]; White and Castle [176]; Klaus, et al. [177]; Kennel et al. [178]; Korner and Thomas [179]; Neal [180]; Woodcock [181]; Rapoport [182]; Ayers [183]; Barnard [184]; and Ainsworth [185] are consistent with this point of view.

Conversely, this emphasis upon the primacy of near receptors for infant development is at variance with the distance receptor school of thought which gives primacy to visual and auditory sensory processes for the motor-mental and social-emotional development of the infant. This latter point of view is reflected in the writings of Walters and Parke [186]; Rhinegold [187]; and Bowlby [188] to mention a few.

The study of Rapoport [182] requires special comment since normal attachment behaviors and emotional and intellectual development were reported in a boy characterized by congenital insensitivity to pain with loss of tactile sensitivity and temperature sensations. Vision and hearing were normal and kinesthetic sensation was intact. Verbal intelligence was normal but motor development was delayed. Maternal attachment was reported to be markedly warm. (Rocking and head banging was the only deviant behavior noted.) Rapoport [182] concluded from this clinical case study that "auditory, visual, and kinesthetic stimuli may be sufficient in the absence of tactile stimulation for initiation and maintenance of attachment behavior" (p. 67).

In evaluating the above conclusion it is necessary to recall that visual sensory deprivation in animals and children does not lead to disturbed social-emotional behaviors. Additionally, the study of Bowyer and Gillies [189] reported that partially and severely deaf children had no greater incidence of maladjustment than children found in an unselected school population. Specifically, they found no significant differences between the partially and severely deaf on a variety of social and emotional adjustment measures. It is of some interest that significant differences in "adjustment" were reported between two schools for the partially deaf and that these differences were "connected with the encouragement of *free movement* and

spontaneous conversation in the classroom in schools" (p. 307, *italics mine*). Similarly, Williams [190] reported that in a group of 51 maladjusted deaf children the psychiatric disorders encountered were similar to those found in hearing children and those handicapped in other ways. Specifically, those children who were characterized with anti-social disorders were noted to have suffered from severely disturbed home backgrounds. It is of more than passing relevance to note the observations of Ling and Ling in these proceedings that mothers of hearing impaired children use much less body contact with their children than did a contrast group of mothers of normal children.

It appears to be necessary to distinguish between somesthetic-cutaneous and kinesthetic-vestibular stimulation in the evaluations of the effects of body contact and movement. The role of kinesthetic-vestibular and kinesthetic-proprioceptive (muscle, joints, tendons) stimulation in contrast to somesthetic-cutaneous stimulation in the Rapoport [182] study is a case in point. The studies of Decarie [191] and Roskies [192] upon thalidomide-induced congenital malformation, where there is abnormality or absence of the limbs (phocomelia), are relevant to the Rapoport case. Decarie [191] found no relationship between the severity of malformations and psychosocial development and observed that the severity of the child's handicap did not seem to be the most significant factor in the behavioral development of thalidomide children. Rather, prolonged and repeated hospitalization, placement in foster homes and particular family circumstances were cited as significant contributing factors to aberrant behavioral development. For example, Roskies [192] reports one mother's comment on the effects of hospitalization upon her thalidomide child: "Because of her hospitalizations, I toilet trained X three times and taught her to walk four times. I don't think I could begin again" (p. 222). As Roskies [192] points out, the above factors, plus the complexity and multiplicity of anomalies produced by thalidomide makes it almost impossible to rank order thalidomide children in terms of severity of impairment and thus makes it difficult to attribute deficits of behavioral

development to phocomelia alone. Unfortunately, it is beyond the scope of this paper to treat more systematically the rich data base obtained from studies of thalidomide damaged children or to attempt to more specifically relate phocomelia, as a sensory deficit, to behavioral developmental processes. It is of interest to note, however, the failure to find EEG abnormalities in thalidomide children by Pampiglione [193], which provides further evidence that deficiency of kinesthetic-proprioceptive stimulation is not as serious for normal development as might be assumed. The emphasis upon movement, i.e., kinesthetic-vestibular stimulation as essential for normal behavioral development is given further support by the study of Siegel [194] who reported marked improvement in the social-emotional behavior of autistic children with movement therapy. Similarly Schopler [195] in his review of the role of receptor processes in autism gave emphasis to sensory deprivation of the near receptors and the efficacy of therapy of stimulation to these receptors (touch and movement). Finally, it should be noted that Korner and Thoman [179], cited earlier, concluded from their study that "vestibular stimulation which attends most caretaking activities may be more crucial than contact for certain aspects of early human development" (p. 67).

The above analyses of selected experimental and clinical data on the effects of sensory deprivation have led to the conclusion that kinesthetic-vestibular sensory stimulation is of primary importance for motor-mental and social-emotional development. This writer is not aware of any studies that report congenital vestibular neuropathy in humans nor surgically induced vestibular sensory loss (partial or complete vestibular deafferentation) in animals reared in a normal maternal-social environment. I have previously suggested this study to critically test and evaluate the role of vestibular stimulation and deprivation upon developmental processes [35].

## THE SENSORY BASES FOR ATTACHMENT

It would appear helpful to emphasize more clearly the differences between the various sensory systems and their role in social-emotional development, particularly, the acquisition and measurement of attachment behaviors. Bowlby [188] has summarized his view on the relative roles of the different sensory receptors as follows:

"Both in these experiments and in the everyday settings the social stimulation reported as being effective in promoting attachment behaviour comprises a mixture of visual, auditory, and tactile, and usually kinaesthetic and olfactory stimulation as well. Questions thus posed are: which, if any, of these modes of interaction are indispensable for attachment to develop, and which are the most powerful for this purpose?

In discussions of the subject two trends are noticeable. In much of the earlier literature, which assumed that attachment developed as a result of a child's being fed, emphasis was placed on tactile, and particularly oral, stimulation. More recently, this supposition has been challenged, especially by those such as Rheingold (1961) [187] and Walters and Parke (1965) [186] *whose theoretical position is similar to that adopted here.* These workers emphasize that, from quite early weeks, an infant's eyes and ears are active in mediating social interchange, and they call in question the special role hitherto attributed to tactile and kinaesthetic stimulation. Not only smiling and babbling, but eye-to-eye contact also seems to play a very special part in developing a bond between infant and mother (Robson, 1967), [196]." (*italics mine.*)

"At first reading it might be thought that the view that visual rather than tactile and kinaesthetic stimuli are prepotent receives support also from a study of the development of attachment

in infants who are averse to being cuddled, reported by Schaffer and Emerson (1964b) [197]. Such a conclusion would, however, hardly be warranted" ([188] p. 319), [197-198].

"The truth is that data do not yet exist for answering the questions posed. That the distance receptors play a far more important part than they have hitherto been accorded seems indubitable, but this is far from concluding that tactile and kinaesthetic receptors are unimportant. On the contrary, when an infant is much distressed, bodily contact seems vital, whether it is in soothing a crying infant during his early months or, a little later, in comforting him when he is frightened. The wisest position to take at present is that in all likelihood all modes of social interaction play a major role, but that, thanks to considerable redundancy in the organisation of attachment behaviour, a shortfall in one mode can, perhaps within wide limits, be made good through some other mode. A plethora of alternative means by which the requirements of survival can be met is, it is known, very common in the animal kingdom." ([188] p. 321.)

Although Bowlby gives primary emphasis to the distance receptors his ambivalence on the subject is still evident and is illustrated in Figure 18 which is the cover of Bowlby's text *Attachment and Loss*, Vol. 1, *Attachment*, which emphasizes the near receptors in the maternal-infant relationship. This writer is in fundamental disagreement with Bowlby's viewpoint that the sensory systems are relatively equipotential in their functional compensatory abilities. Specifically, the distance receptors cannot compensate for loss of physical affection and somatic pleasure consequent to somatosensory deprivation. Additionally, Bach-y-Rita has demonstrated in these proceedings and elsewhere [113] that the skin senses can be utilized to induce visual perceptions whereas the converse is not true, namely, retinal stimulation cannot induce skin perception.

## ATTACHMENT AND LOSS

VOLUME I

### ATTACHMENT

John Bowlby



Figure 18. Cover. From J. Bowlby, *Attachment and Loss* (86)

It needs to be emphasized that sensory deprivation to the near receptors in contrast to sensory deprivation to the distance receptors have fundamentally different consequences to the developing organism. For example, Mason [65] demonstrated that infant monkeys reared in isolation with mechanical moving surrogate mothers did not develop movement stereotypes which were developed by infant monkeys reared in isolation with a stationary surrogate mother. Neal [180] demonstrated that mechanical rocking of human prematures facilitated their health status and maturation of sensory-motor functions.

Sackett [158] in his review of the factors contributing to abnormal behaviors and thus amelioration in the partial isolate concluded:

"The presence of early visual and auditory contact is not therefore sufficient to produce adequate social development in partial isolates. . . thus visual

and auditory exposure to a social stimulus is not sufficient for permanent attachment formation but seemingly must be accompanied by actual physical contact as a crucial stimulus dimension." (p. 120)

In another review by Sackett [159] concerning the effectiveness of various therapies he concluded:

"The PI monkeys in these studies all received social and nonsocial experience after the first year of life. The persistence of behavioral deficits, even after extensive 'therapy' experience suggests that *rearing without physical peer contact* produced animals unable to adapt adequately to many social and non-social situations." ([159], p. 33) (italics mine.)

Harlow, Suomi and their co-workers [152; 160-162; 169] have recently described successful therapy with monkeys reared in total social isolation for the first six months of life which is known to consistently produce severe deficits in virtually every aspect of social behavior. In the above studies it was pointed out that:

- a. young isolates exposed to equal-age normal peers achieved only limited recovery of simple social responses;
- b. some mothers reared in isolation eventually exhibited acceptable maternal behavior when forced to accept infant contact over a period of months but showed aversion for the contact;
- c. isolate infants exposed to surrogates were able to develop crude interactive patterns among themselves; and
- d. six month old social isolates exposed to three month old normal monkeys achieved essentially complete social recovery for all situations tested.

In the above studies it was emphasized that normal equal-age peers would frequently attack the partial isolate while the three month old monkey had not yet developed aggressive behavior patterns and would cling

to the older six month old. It was concluded:

"The role of *gentle physical contact* and model-serving exhibited by the therapists was likely of paramount importance for isolate recovery" (Suomi, et al. [160]). (italics mine.)

The above brief overview of some primate isolation rearing studies with other data not reviewed here but elsewhere (Prescott, [35, 36]) has compelled this writer to conclude that of all the sensory systems involved in primate social relationships the somatosensory system is the crucial sensory system for the development of normal social emotional behaviors; its deprivation during the formative periods of development is responsible for the variety of abnormal social emotional behaviors observed consequent to "social" isolation; and effective "therapy" for their behavioral disorders must include somatosensory stimulation of a pleasurable-affective nature.

A plea is made to reconceptualize the "social" deprivation studies as "sensory" deprivation studies and that concerted efforts be established to examine the neurobiology of brain structure and function in animals so deprived. This reconceptualization should give greater validity to extrapolating non-human primate behavior to human primate behavior as discussed in more detail elsewhere (Harlow and McKinney [199]). Finally, a major task remains to determine how much somatosensory deprivation in the human infant is sufficient to induce abnormalities of behavior or conversely, how much physical affection is required by the human infant and child to ensure its normal social and emotional development. These issues are explored elsewhere (Prescott, [36]).

Another example of this issue are the Schaffer and Emerson [197-198] studies of "cuddlers" versus "non-cuddlers." It should be noted that differences between these infants do not reflect differences between near-receptor and distance-receptor functioning. Rather, they reflect intra-somatosensory differences, namely, the "cuddlers" are *somesthetic* types and the "non-cuddlers" are *kinesthetic* types. The non-cuddlers are quieted by *movement* stimulation, e.g., being

thrown up and down in the air, wheeled in prams, swung in swings, etc. [57; 197, 198]. It has been suggested previously that cuddlers may reflect, in part, mothers who are active during pregnancy; and conversely non-cuddlers may reflect, in part, mothers who are relatively inactive during pregnancy [57]. This suggestion, however, requires evaluation. Thus, the Schaffer and Emerson [197, 198] studies can be interpreted to give primacy to somatosensory-stimulation variables in the mother-infant relationship.

The issues of attachment vs. dependency have been dealt with extensively elsewhere [200-204]. It is beyond the scope of this paper to elaborate much further on the relevance of specific sensory systems to the attachment/dependency controversy. Suffice it to say that this writer has previously suggested that a major difficulty in distinguishing between attachment and dependency behaviors resulted from using the behavior or *responses* of the child as differentiating criteria [57]. Within the context of the somatosensory theory of socialization, it was proposed that attachment behaviors result from somatosensory stimulation and dependency behaviors result from somatosensory deprivation [57]. Thus, the distinction between attachment and dependency derives from the nature of the *sensory* environment experienced during the formative periods of development and not from the behavioral response repertoire of the child. Further, a psychophysiological assessment of "dependency" and "attachment" was suggested [46; 57] which was based upon the observation that impaired habituation is a consequence of sensory deprivation during the formative periods of development [46; 57]. Thus, it would be expected that "dependent" children would habituate less readily to somatosensory (tactile and vestibular) stimulation than would "attached" children; and that the form or rate of habituation to visual and auditory stimulation would be different from somatosensory stimulation in the "dependent" child whereas no such differences would be expected to be obtained in the "attached" child. Systematic differences should also be found in nystagmus activity consequent to caloric, rotational and optokinetic stimulation.

These psychophysiological assessment procedures are of primary relevance to the study of crosscultural differences in child rearing practices, particularly where large differences in somatosensory stimulation of infants and children are observed [46; 57; 36; 205, 206]. A more complete rationale for these suggestions have been provided elsewhere and it has been emphasized herein to further support the differential importance between near-receptor and distance-receptor functioning for developmental social behaviors [35, 36; 57]. This is particularly relevant for understanding the unique problems associated with the sexual behaviors of the blind (Gillman and Gordon [207]; Prescott [208]).\*

## CEREBELLAR MECHANISMS OF BEHAVIOR

In concluding this paper it would seem appropriate to summarize briefly the neurophysiological properties of the vestibular-cerebellar structures and their relevance, as a regulatory system, to the issues discussed above.

First: The cerebellum is one of the most immature mammalian brain structures at birth and therefore is highly vulnerable to a variety of early postnatal insults, e.g. insufficient sensory stimulation for normal growth, development and function; malnutrition; neonatal anoxia; hyperthermia; viral infections; environmental toxins; etc. (Prescott [35, 36]). Specifically, Altman [209] and Howard [211] have reported upon the postnatal growth of the rodent cerebellum where the latter author has indicated a 580 percent postnatal increase of cerebellar DNA and a 25 percent postnatal increase of cerebral DNA from day 2 to 15 which represents the percent growth of those structures during that postnatal period. Howard, et al. [210] have studied the increase of DNA in cerebrum and cerebellum during development of the human fetus and demonstrated an *exponential* increase in total cerebellar DNA that was not found for cerebrum. Since it is unlikely that an exponentially increasing rate of cell division would be abruptly terminated, these results suggest the presence of a significant amount of *postnatal cell division* of

\*Personal communication.

neuronal precursors in the human cerebellum in contrast to the cerebrum. It should be noted that DNA reflects the actual number of nuclei where the cells are diploid. Although Purkinje cells are uniformly tetraploid by six months after birth in the human and since there are approximately 1000 granule cells to each Purkinje cell, the errors of estimate introduced by the tetraploid Purkinje cells are considered minimal given the number of granule cells in total cerebellum ( $10^{10}$ ) [59]. The studies of Ellis [212] and Raaf and Kernohan [213] report gradual increases in the thickness of the external granular layer in human cerebellum to 10 to 20 months of age. Meyers [214] provides data on the percentage of growth of the cerebellar molecular layer from six months of fetal life until two years after birth. These data indicate that cerebellar cell development is not complete until age two. Winick, et al. [215, 216] have described the effects of severe malnutrition upon cell development in cerebrum and cerebellum in children and found that reduction of cell division by malnutrition appears to level off at about 12 months for cerebral cortex and at about 16 months for the cerebellum. Lapham\* has expressed the point of view that the morphological development of the cerebellum spans the first two years of life and that physiological maturation continues for several years in the human.

Second: The cerebellar cortex has perhaps the highest cell density of any neural structure of the brain where estimates of the density of granule cells are from 2.5 to 7 million cells per cubic millimeter. The total number of granule cells in the whole cerebellum are estimated at  $10^{10}$  [59]. It would appear that such cell density and complexity would involve more than the regulation of motor functions. Models of the cerebellum involving pattern perception and memory processes are dependent, in part, upon this high cell density [105-108].

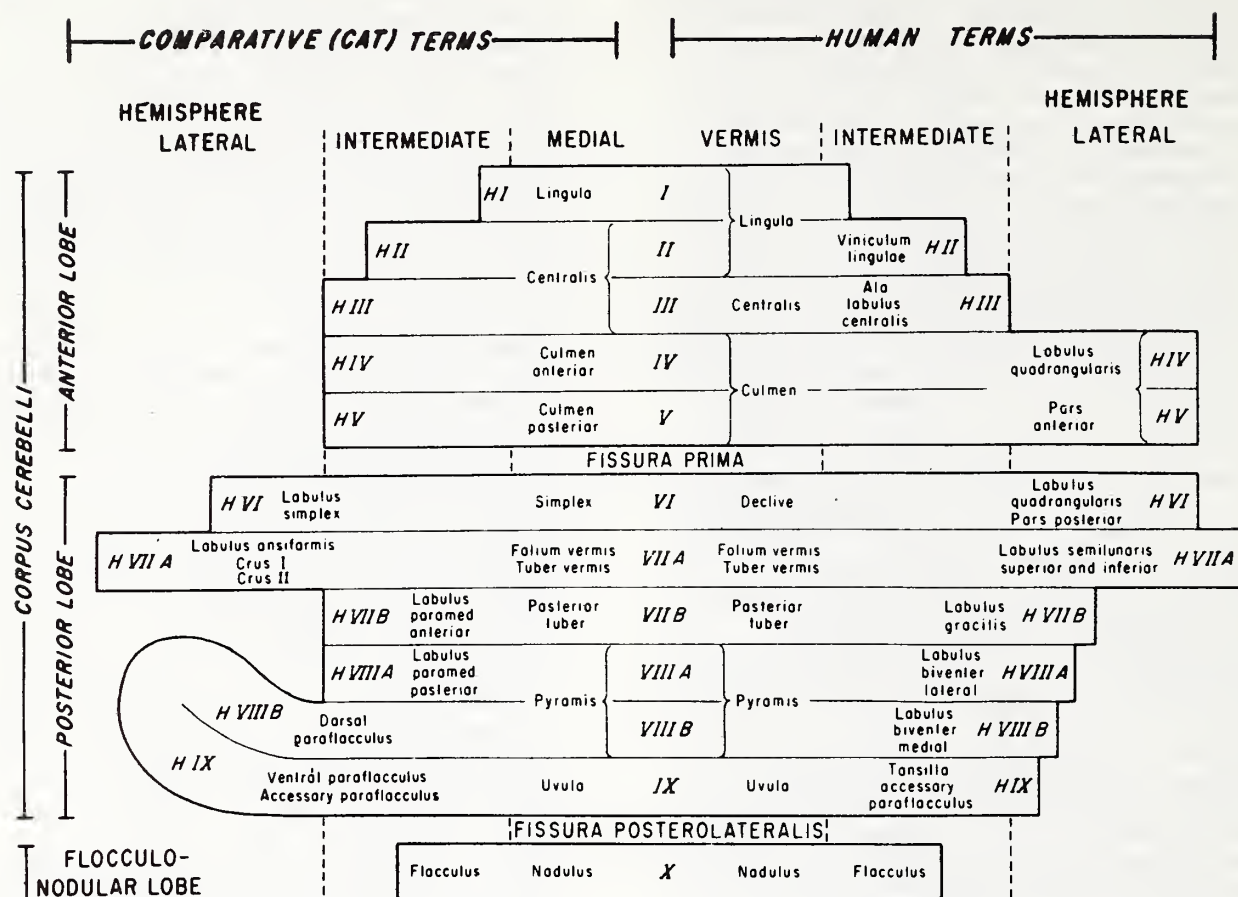
Third: It has been previously proposed that the cerebellum may be a master regulatory system for sensory-emotional-motor processes [35; 57] and that the organization of sensory projection fields within cerebellar

cortex suggests a neurophysiological basis for the behavioral distinction of near-receptor and distance-receptor functioning. Figures 19 and 20 present a highly schematized representation of the gross morphology of the mammalian cerebellum and Figure 21 presents the specific sensory projection fields upon the cerebellar cortex for auditory, visual and somatosensory inputs. As can be seen, the sensory projection fields of somatosensory inputs (near-receptors) are different from and relatively independent of the visual-auditory sensory projection fields. Further, the projection fields of visual and auditory inputs (distance receptors) to the cerebellar cortex are co-extensive and overlap; the projection fields of somatosensory inputs (near receptors) are different from and relatively independent of the projection fields of visual-auditory afferents to the cerebellar cortex. Figure 22 presents the vestibular sensory projection fields upon cerebellar cortex and it can be seen that these sensory projection fields are completely different from the projection fields for the other sensory modalities except for a small overlap in the lingular of the anterior lobe. The cerebellum may well process sensory information from the distance receptors and near receptors as distinct functional units which would seem to provide a neurophysiological basis for the behavioral distinction between near receptor and distance receptor functioning in developmental processes. It is of interest to contrast the organization of sensory projection fields within the reticular formation to that of cerebellar cortex. Groves, et al. [218] reported a distinct and differentiated localization with some overlap of visual and auditory projection fields within the reticular formation but found that cells responsive to tactile stimulation were evenly distributed throughout the reticular formation which were somatotopically organized. The anterior, middle and posterior thirds of the body surface projected, respectively, to the anterior, middle and posterior portions of the reticular formation. Unfortunately, vestibular afferents were not studied. It should also be noted that the cerebellum does not mature uniformly and that the differential maturation of specific regions within the cerebellum has important implications for development which cannot be elaborated

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\*Personal communication.

### HIGHLY SCHEMATIZED REPRESENTATION



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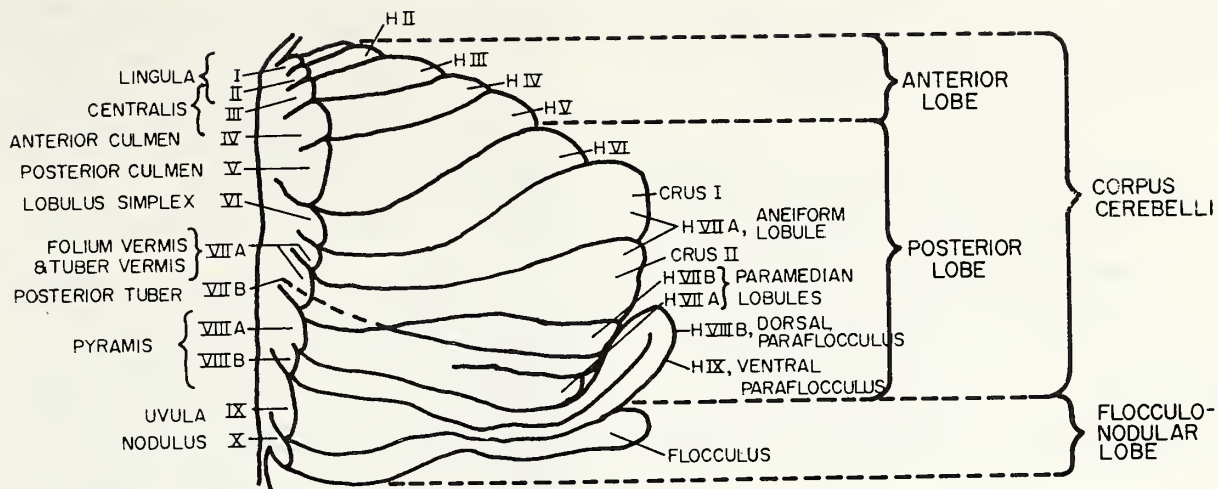


Figure 20. Generalized structure of the mammalian cerebellum, showing the vermal and lateral folial patterns [modified from Dow, 1961]. For the nomenclatural details, see Figure 24.

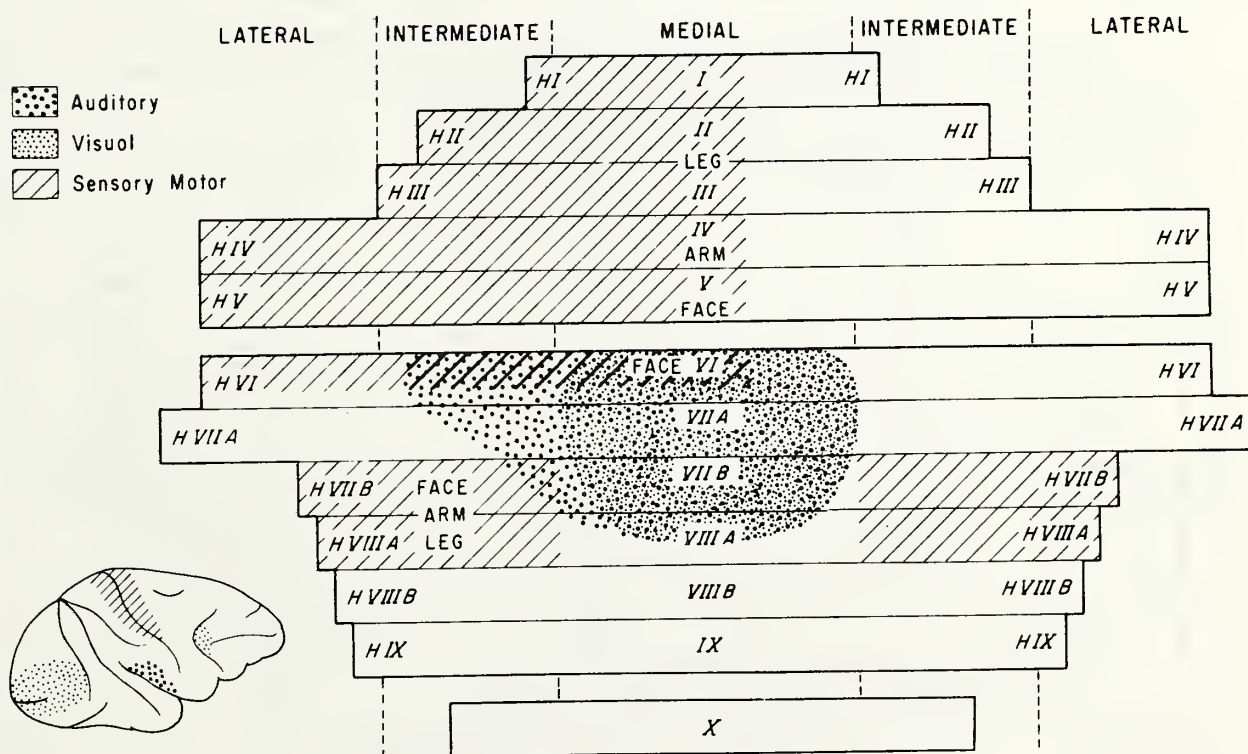


Figure 21. Diagram of projection areas of specific cerebral cortical regions onto the cerebellar cortex of the monkey [Schematized from Snider and Eldred, 1952, Fig. 4, p. 35].

upon herein [219]. Figures 23 to 25 illustrate some of the unique relationships of specific cerebellar cortical brain regions to other brain structures.

With respect to *input* and *output* characteristics of cerebellar cortex it should be noted that the only *inputs* to cerebellar cortex from outside the cerebellum are the *mossy* and *climbing* fibers and the only *output* from cerebellar cortex is the inhibitory *Purkinje cell axons*. Brain-tenberg [220, 221] has emphasized this simplicity of input and output as one of the unique features of the cerebellar cortex.

Multiple independent inputs of information have been considered to be a functional characteristic that enhances accuracy and reliability of a regulatory control system. It is with that principle in mind that the organization of sensory inputs into various brain structures should be considered in attempts to relate

structure to function. Input characteristics, however, are only one feature of a regulatory control mechanism. Output characteristics and interactions between inputs and outputs are also essential elements of a regulatory control system and these are described below with respect to cerebellar functioning.

Fourth: The *output* functions of the cerebellum are characterized by the nature of neural activity, i.e., excitatory and inhibitory neural processes and not by sensory modality processes. This cerebellar characteristic is in marked contrast to that of cerebral cortex. There are only two output systems from the cerebellum, namely, (a) cerebellar cortex; and (b) the deep cerebellar nuclei. Specifically, the efferent projections from cerebellar cortex (Purkinje system) are exclusively *inhibitory* in nature; and the efferent projections from the deep cerebellar nuclei are exclusively *excitatory* in nature. The cerebellar

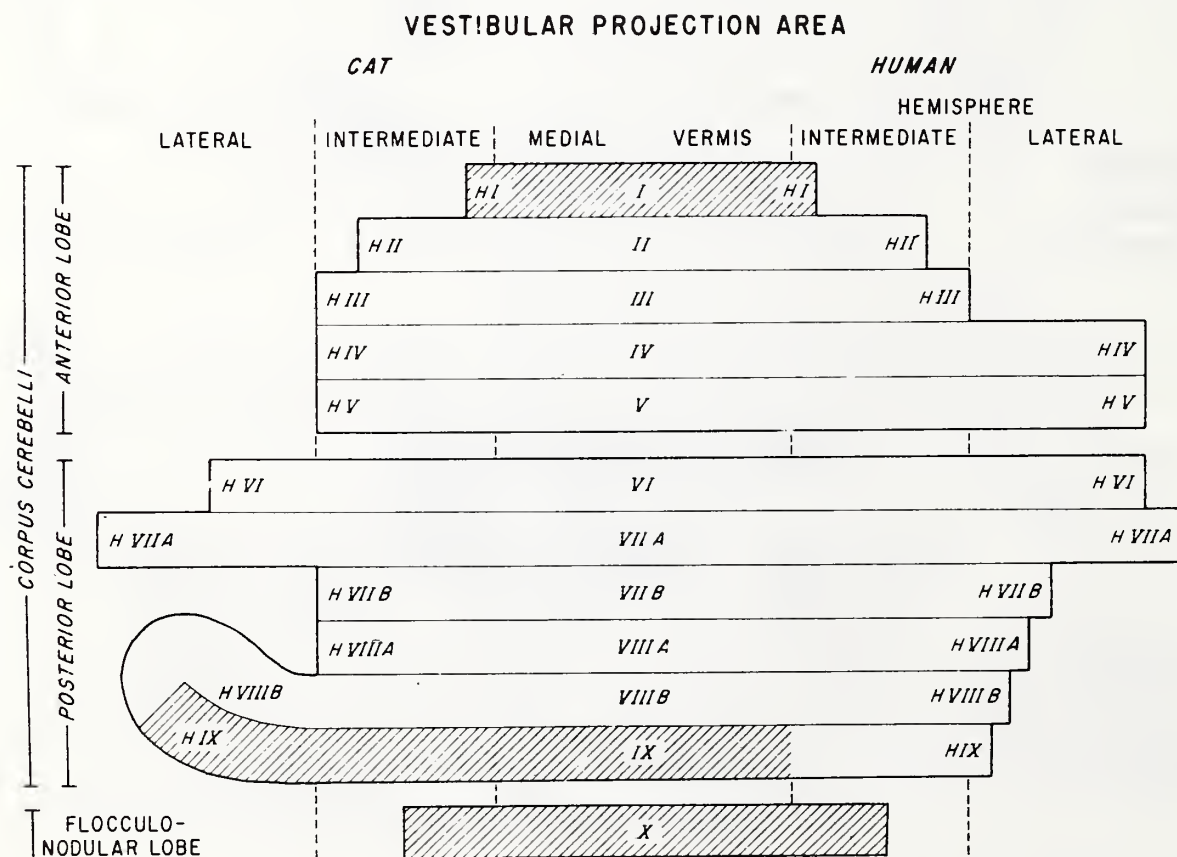


Figure 22. The vestibular projection areas on the cerebellar cortex are shown by cross hatching. Direct fibers from the labyrinth terminate ipsilaterally while secondary fibers from the vestibular nuclei are distributed bilaterally. [Dow]

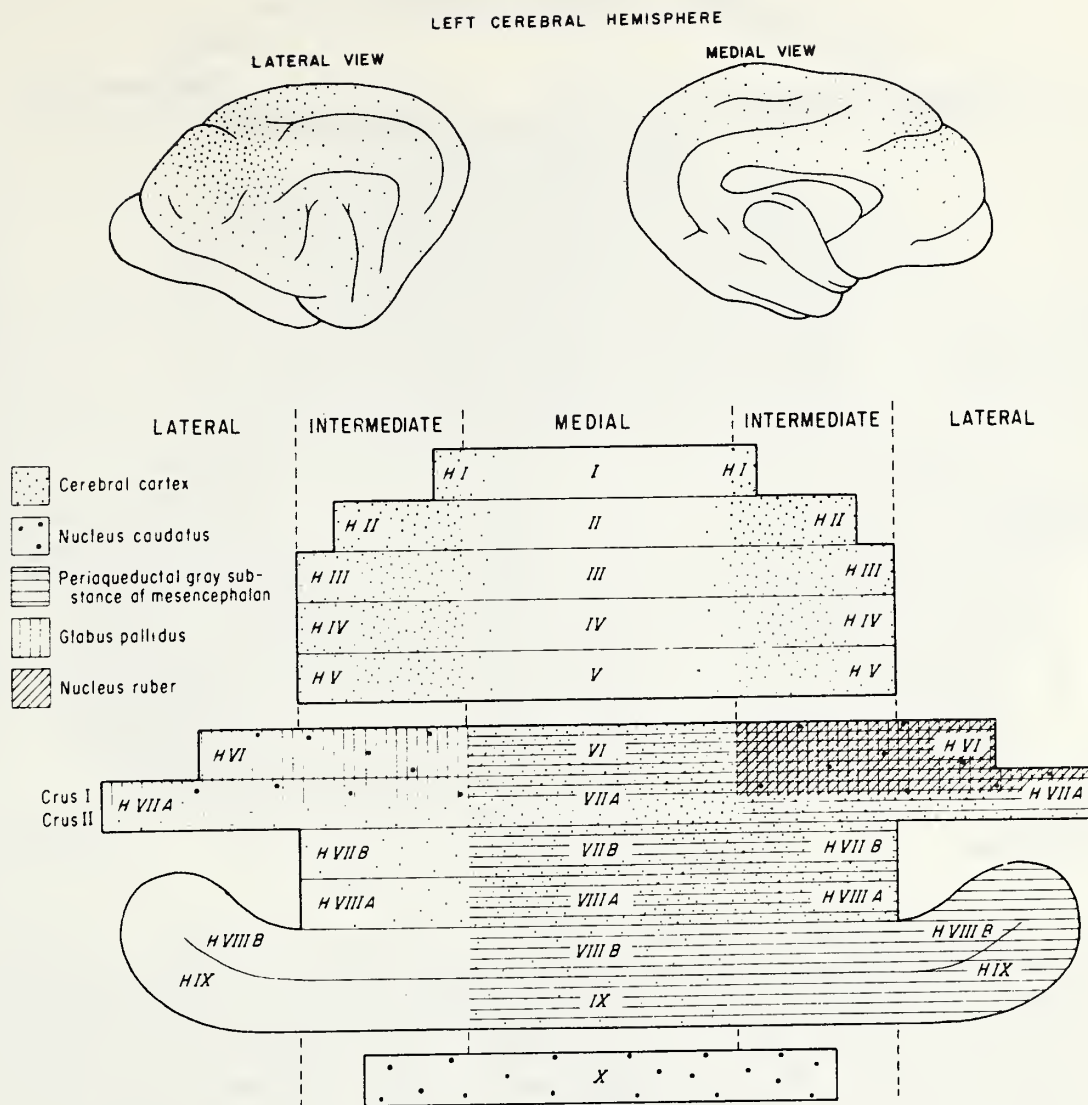


Figure 23. Diagram representing the ultimate termination of afferents to the cat cerebellum from specific rostral areas of the left side of the brain via specific parts of the inferior olive. The origins of the projections, i.e., cerebral cortex, caudate nucleus, globus pallidus, periaqueductal gray substance of the midbrain, and red nucleus, are shown by various types of shading. Above the schematic diagram of the cat cerebellum the left cerebral hemisphere is shown; the more dense stippling differentiates the sensorimotor area and its cerebellar connections. The unshaded medial area of the anterior lobe receives olivary afferents from the accessory part of the inferior olive that has its afferent connections from the spinal cord. [Schematized from Walberg, 1956, Fig. 23, p. 134.]

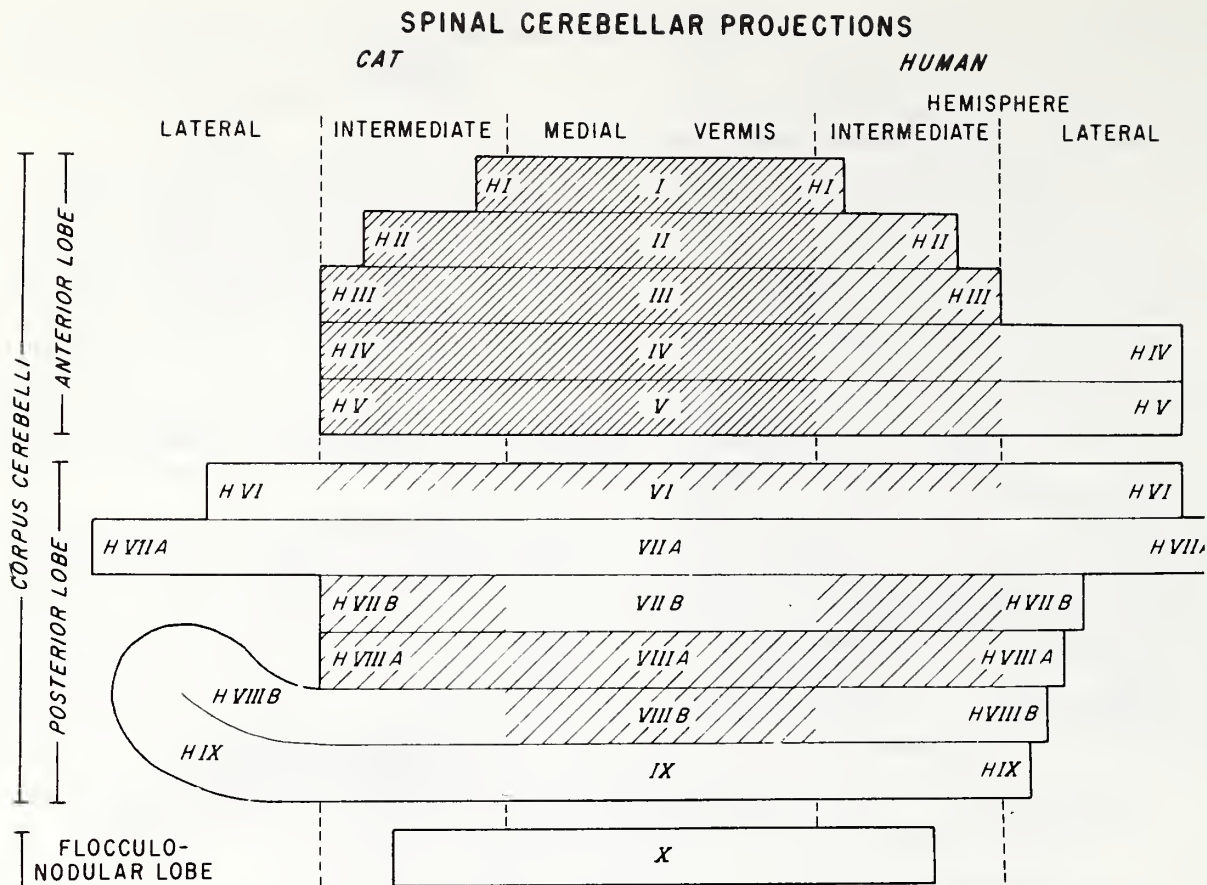


Figure 24. Spinocerebellar projection on the cerebellar cortex. The spacing of the lines indicates the density of the connections. The connections to the anterior lobe are almost entirely ipsilateral, i.e., fibers from one side of the body go to the same side of the anterior lobe. The projection to the paramedian lobules, however, is bilateral. For details, see Oscarsson, 1965. There is some evidence that the projection in primates is relatively denser medially and is encroached upon by pontine projection laterally (Dow, 1942b). This difference between subprimates and primates is shown by differences in density of shading on the left and right halves of the diagram. [Dow]

cortical Purkinje axons project to the deep cerebellar nuclei and to other brain structures. Thus, the neural excitatory output from the deep cerebellar nuclei is modulated by Purkinje *inhibitory* efferents from cerebellar cortex. This differentiated output characteristic of cerebellar activity should also contribute to the enhancement of accuracy and reliability of cerebellar functioning in its role as a regulatory control system. It is, of course, recognized that the cerebellum is subjected to a variety of neuronal influences from other brain structures but it is beyond the scope of this paper to

describe these relationships which have been more adequately presented elsewhere [59; 222, 223].

Fifth: The cerebellum has a *structural horizontal* organization and a *functional longitudinal* organization. Figures 19 to 27 are illustrative of this organization. Figures 26 and 27 illustrate more vividly the longitudinal organization of cerebellar function which is of particular interest for the proposal that the cerebellum may be a master regulatory system for sensory-motor behaviors. As can be seen from Figures 26 and 27 there is a distinct

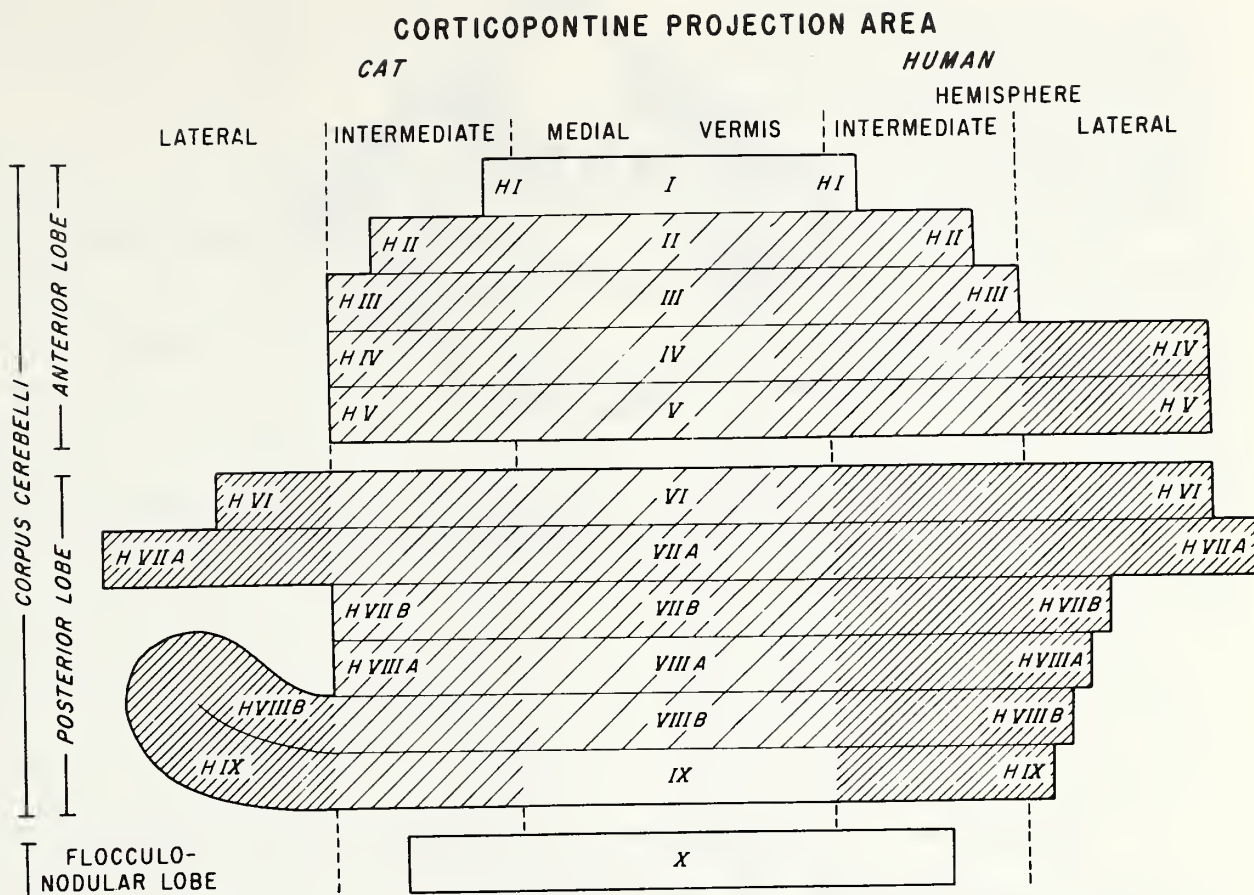


Figure 25. Corticopontine projection area on the cerebellar cortex. The spacing of the lines indicates the density of the connections. Note that in the right-hand side of the diagram which represents the primate cerebellum the corticoponto-cerebellar connections have great density in the anterior lobe and extend further medially than in subprimate animals shown on the left-hand side. Lobule H VIII B and H IX (para-flocculus) is enormous in aquatic forms and receives its mossy fiber input exclusively from the pontine nuclei. [Dow]

relatively non-overlapping relationship between the output of the cerebellar cortex to the three deep cerebellar nuclei. The midline or vermal area of cerebellar cortex projects to the *fastigial* nuclei; the intermediate or paravermis area of the cerebellar cortex projects to the *interpositus* nuclei; and the hemispheric or lateral areas of the cerebellar cortex projects to the *dentate* nuclei. As can be seen in Figure 23 there are highly specific projections of the cerebellar cortical-deep nuclei relationships to other brain structures that are involved in motor functions. The importance of the above interrelationships for the point

of view being presented herein is that the output of the *fastigial* nuclei project primarily to old brain structures, i.e. it represents paleocerebellar functions. The main relationships of the *fastigial* nucleus are with the vestibular nuclei and the pontine and medullary reticular formation. The output of the *interpositus* and *dentate* nuclei projects primarily to new brain structures, i.e. they represent primarily neocerebellar functions. The main relationships of the *interpositus* and *dentate* nuclei are with the thalamic and red nuclei and cerebral cortex [59]. More extensive treatment on cerebral-cerebellar interrelationships



Figure 26. Cross section through cat cerebellum and brainstem [adapted from Sprague and Chambers, 1954]. "Dentate nucleus" is given here for comparative purposes. The correct name for the structure in subprimates is "lateral nucleus."

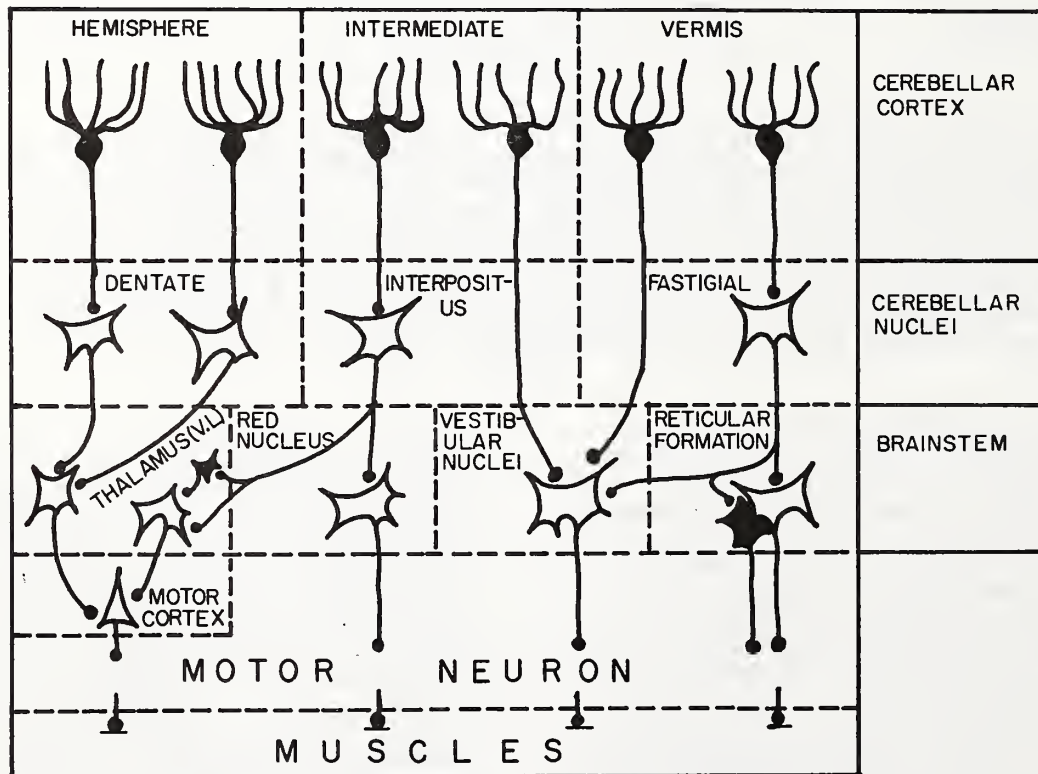


Figure 27. Pattern of outflow from the cerebellar cortex. Black neurons are inhibitory, white are excitatory. The other neurons intervening between those in the brainstem and the motor neurons are not shown. [Figure adapted from Ito, W. S.]

can be found in Evarts and Thach who describe these interconnections in the initiation of motor movement [125, 126].

It needs to be emphasized that cerebellar cortical-cerebellar nuclei relationships are organized according to phylogenetic-evolutionary principles and not in terms of sensory function. Thus, the regulation of behavior through cerebellar functions is mediated not only by the way in which sensory input is organized within cerebellar cortex but also by the way in which cerebellar cortex is organized phylogenetically. Consequently, it is suggested that the cerebellum may be a central processor for the transformation of sensory information into a format that permits a phylogenetic interpretation of that sensory information. The enormous development of the cerebellar hemispheres and their special relationship to cerebral neocortex in the higher primates and some ocean mammals, e.g. the bottlenose dolphin (*Tursiops truncatus*) in contrast to the lower mammals suggests an evolutionary significance for the cerebellum that has yet to be explained [224-231]. These issues seem not unrelated to Lilly's [224, 225] studies on non-human intelligence and language in the dolphin and MacLean's concept of the triune brain [228]. The findings of Gardner and Gardner [232, 233]; Premack [234, 235] and Rumbaugh, et al. [236, 237] that one of the higher primates (chimpanzee-Pan) can learn rudimentary language and the studies of Lilly [224, 225] which indicates that humanoid conversations between the bottlenose dolphin (*Tursiops truncatus* and *homo sapiens*) may be possible, acquire an added dimension when taken within the context of the theories of Marr and Blomfield and of Albus [105-108]. Specifically, these writers propose that the cerebellum may be involved in pattern perception and memory processes which suggest that the extensive development of the cerebellar lateral hemispheres and their special connections to cerebral neocortex in these species (*homo sapiens*, *Pan*, *Tursiops truncatus*) may be related to their language abilities.

This theoretical orientation has some support in the clinical findings of Frank and Levinson [238] who have reported that:

"Of 115 consecutive dyslexic children selected and referred for psychiatric evaluation on the basis of their poor or refractory response to reading instruction, 112 (97%) children showed evidence of a cerebellar-vestibular dysfunction. This cerebellar-vestibular dysfunction manifested itself in the dyslexic children by: positive Rombergs, difficulty in tandem walking, articulatory speech disorders, dysdiadochokinesis, hypotonia, and various dysmetric or past-pointing disturbances during finger-to-nose, heel-to-toe, writing, drawing, as well as during ocular fixation and scanning testing (Dow and Moruzzi, 1958 [239]), ([238], p. 690).

The speculative nature of these suggestions are recognized and it is beyond the scope of this paper to extend these concepts any further. However, they seemed worthy of mention because of their implications for heuristic thinking about the evolutionary significance of cerebellar development and functioning in behavior.

It must be recognized that the above is a highly abbreviated and skeletal outline of the complexity of the brain structure relationships associated with cerebellar functioning. However, in its gross outlines there appears to be an evolutionary or phylogenetic organization of the cerebellum that is related to behavioral patterns and capacities associated with old brain and new brain functions. These features may contribute to the functional role of the cerebellum as a master regulatory system of sensory-emotional-motor processes [35, 36; 57].

Sixth: The cerebellum is also involved in the regulation of autonomic functions which, of course, are directly related to emotional processes. It is beyond the scope of this paper to review these and other interrelationships and the interested reader can consult Dow and Moruzzi [239]; Fulton [240]; Fox and Snider [241]; Adey and Tokizane [242]; Snider [119; 279]; Hockman, et al. [217]; Doba and Reis [243, 244]; Miura and Reis [245, 246] and Moruzzi [223] for this information. Evidence linking cerebellar function to limbic system activity

has been provided elsewhere [35] and based upon these theoretical speculations, Heath and Harper [247-251] have confirmed cerebellar-limbic-frontal orbital linkages which have been previously proposed to be involved in maternal-social deprivation and isolation-reared behaviors [35]. Further, Reis, et al. [252] have demonstrated that predatory attack, grooming and consumatory behavior in the cat can be evoked by electrical stimulation of the cerebellar rostral fastigial nucleus.

The review of Karamyan [227] reported that cerebellar ablations in mammals produced marked disturbances in sensory, motor, autonomic, and emotional behaviors, specifically enhanced sensitivity to touch and pain with increased scratching and licking reflexes, ulcerations in various parts of the body, loss of hair, various gastrointestinal disturbances, and impairment or abolishment of conditional reflex activity which provides further support for a broader view of cerebellar functioning. Berman, et al. [62] have reviewed additional studies on cerebellar mediation of emotional behaviors (pleasure and aggression) and have described the reduction of violent behaviors in isolation reared monkeys consequent to selected cerebellar lesions.

Peters and Monjan [253] have reported taming effects (marked pleasure reactions [kneading and purring] and stroking around the experimenter's legs) in cats following cerebellar vermis lesions. Similar taming effects were found in squirrel monkeys consequent to cerebellar vermis lesions where it was possible to approach and stroke them without difficulty and no fighting or markedly aggressive behavior could be seen after surgery. These authors, however, could not provide any theoretical rationale for their observed results.

Peters, Bleek and Monjan [254] also reported that reactivity to low level shock (below 200  $\mu$ a) was significantly altered by cerebellar vermis lesions but not by cerebellar hemispheric lesions. These differential findings are consistent with those reported by Berman [60, 61] and Berman, et al. [62] where marked reduction in aggressive behaviors consequent to cerebellar vermis lesions

but not cerebellar hemispheric lesions were reported. The additional findings of Peters, et al. [254] of differential responding to low level and high level shock (above 200  $\mu$ a) where no differences between the groups for high level shock was reported needs to be placed in the context of Sackett's [159] findings that isolation reared rhesus monkeys would avoid water tubes with low current levels (hyperreactivity) which normal animals would tolerate; yet maintain contact with the water tube that had high current levels, even when tissue damage would occur (impaired pain perception) which normal animals would avoid. These findings need to be clarified since this writer has previously implicated cerebellar functioning in mediating hyperreactivity to tactile stimulation and impaired pain perception in the isolation reared syndrome. The conclusion of Peters, et al. [254] that the findings of Sprague and Chambers [255], where midline lesions of the cerebellum reduced reactivity to painful stimuli, could not be supported, seems premature in the context of other findings. Specifically, Siegel and Wepsic [256] reported a 350 to 400% elevation in nociceptive thresholds to painful tail shocks in monkeys when cerebellar areas whose efferents traverse the brachium conjunctivum were stimulated (paleocerebellar system). These effects were not obtained when cerebellar areas related to the brachium restiformis were stimulated. These authors noted that this differential effect was "not surprising as the brachium conjunctivum carries impulses to the reticular formation (RF) of the mesencephalon, pons, and medulla which in turn affect non-specific thalamic as well as brain stem and spinal cord sensory areas" (p. 192). These findings are particularly consonant with this writer's theoretical neural model that hyperexcitability of cerebellar cortex induced by partial functional deafferentation (isolation rearing) according to Cannon's *Law of Denervation Supersensitivity* results in an excessive outflow of cerebellar cortical efferent activity which inhibits those brain structures associated with somesthetic afferent activity [35; 46]. This model is similar to that advanced by Siegel and Wepsic [256] only the *mechanism* by which cerebellar cortex is activated is different. In addition, the neural

model of this writer interprets the waxing and waning of the hyperexcitable neurons (Ward, [257]) as a possible mechanism to account for the aversion of hyperreactivity to touch and the impaired pain perception observed in the isolation reared animal [35]. In this context, the cerebellum should be considered in therapeutic efforts to regulate and control pain (and pleasure) experiences. Additionally, Ward [257] observed that anatomical studies indicated that the hyperexcitable neurons (in the epileptic focus) are "characterized by a striking loss of dendritic spines" (p. 379). This of course, is a classic effect of early sensory deprivation and provides further support for Cannon's *Law of Denervation Supersensitivity* at the central nervous system level [44-46; 48; 258].

Equally significant is Ward's [257] observation that "cells in the epileptic focus are difficult to evoke into activity by afferent synaptic input"--and that this reduction of input to cortical neurons may play a role in the genesis of the hyperactive state that underlies epilepsy" (p. 329). If we substitute the terms behavioral hyperactivity, hyperreactivity and impulse dyscontrol which includes aggression for "epilepsy" then we have an even greater congruence of theory, data and neural mediating processes. Thus, similar neural processes may be involved in different neurofunctional systems which relate to epilepsy and other kinds of behavioral dyscontrol syndromes. It also suggests that an enriched and superthreshold afferent input into cells in the epileptic focus might reduce if not eliminate epileptic seizure discharges where the source of disorder of the epileptic focus resides elsewhere in the nervous system. This possibility has been dramatically demonstrated by Tassinari [259] where he suppressed focal spikes by somatosensory stimuli in an 11 year old boy. This patient had a right hemiparesis that followed a traumatic delivery with subarachnoid haemorrhage that resulted in seizures at 8 years of age in the left fronto-parietal area with spreading to the midline regions. During wakefulness the seizures were characterized by bi-or triphasic spikes with an amplitude of 100-150  $\mu$ v which recurred rhythmically at 3-4 Hz. The response of the patient to sensory

stimuli is best described by Tassinari [259]:

"(a) Effective stimuli: the continuous rhythmic spikes were suppressed by passive and voluntary movements of flexion or extension of the right foot, such as during the Babinski manoeuvre. Suppression of the spikes by such stimuli--which will be referred to as *effective stimuli*--was constant, reproducible at will, and persisted without habituation. The effective stimuli blocked the spikes regardless of anticipation. In all instances, the spikes reappeared immediately after the end of any form of stimulation. Contemplation of movement only did not suppress the spikes.

(b) Ineffective stimuli: tactile stimuli and passive and voluntary movements involving regions other than the right foot did not modify the spike activity. Visual and acoustic stimuli, mental activity (calculation, reading) and situations of emotional stress did not modify the spike activity." (pp. 574-575)

It is also of interest that the stimuli effective during wakefulness also suppressed spike activity during rapid eye movement (REM) stages of sleep but were ineffective during stages 2, 3 and 4.

Tassinari [259] interpreted the spike rhythm in his patient as a result of a cortical lesion resulting from partial deafferentation. He noted that:

"Decreased somatosensory input by posterior chordotomy facilitates the synchronization of the cortical activity in the corresponding regions of sensory projections (Anderson, 1962 [260]), and may even produce frank epileptiform activity in the thalamic (VPL nuclei) and cortical (somatosensory) regions (Bava, et al., 1966 [261])." (p. 577)

His discussion of this phenomenon is particularly relevant:

"The electrical activity in chronic partially isolated somatosensory cortex is characterized by: (a) the appearance of paroxysmal bursts of slow waves, which are progressively replaced by spike discharges (Grafstein and Sastry, 1957 [262]; Echlin and Battista, 1963 [263]); (b) by high voltage evoked potentials in response to local electrical stimulation or to afferent stimuli applied to peripheral nerves (Burns, 1950 [264]; Echlin and Battista, 1961 [265]); (c) by the occurrence of subclinical seizures, spontaneous or induced by repetitive stimulation of peripheral nerves (Echlin and Battista, 1961 [265]). Similar features were also found in this case.

The importance of the passage of time in determining the continuity and rhythmic of the spikes is stressed since these patterns appeared 10 years after birth. The rhythmicity of the spikes could result from a progressive increase in the excitability of a partially isolated area, or from a change in the degree and quality of the afferent input "driving" the hyperexcitable neurons into rhythmic activity. It was found by Burns (1950 [264]) and by Echlin and Battista [1961 [263] and 1963 [265] that "the spontaneous" activity in the partially isolated cortex (somatosensory area) was largely dependent on the afferent input to this area" (p. 577).

It is also of interest that Tassinari [259] interpreted the failure of the effective somatosensory stimuli to suppress spike discharges during sleep stages 2, 3 and 4 as a consequence of additional functional deafferentation associated with slow stages of sleep; and that the failure of generalized tonic contractions to suppress spike activity might be attributable to cerebellar inhibitory efferent activity resulting from seizure discharge stimulation of the cerebellum.

Although Tassinari [259] reported the failure of "mental activity" (representing right foot stimulation)

to reduce spike discharges it should be noted that Sterman and Friar [266] were able to suppress epileptic seizures following sensorimotor EEG feedback training.

Studies reviewed earlier in this chapter that enriched somatosensory stimulation can reverse behavioral abnormalities of somatosensory deprived (isolation reared) animals are consistent with Tassinari's [259] findings. The findings of Nyhan [64] reviewed earlier herein are particularly cogent since rotational-vestibular stimulation of nine additional DeLange children resulted in a prompt initiation of smiling, laughter and joy. Prior to this vestibular rotational stimulation these DeLange children were characterized by a bland, affectless emotional state. This writer interpreted these additional findings as further support for the role of the vestibular-cerebellar neuroaxis in regulating emotional behaviors [267].

Additional evidence related to this cerebellar hypothesis is Moruzzi's [223] demonstration and description of the diphasic functioning of the cerebellum:

"The stimulation of the interior of the cerebellum in the diencephalic cat is followed by responses which are strikingly different from those observed by Magoun, Hare and Ranson [35, 268] in their decerebrate preparations. They have found that faradization of midline structures evokes a decrease of ipsilateral rigidity, followed at the end of the stimulation by a powerful extensor rebound. This diphasic character of the paleocerebellar response is still observed in Bard's preparation, but the sphere of influence is now no more restricted to the postural tonus. Inhibition and rebound facilitation of autonomic and somatic manifestations of sham rage clearly dominate the picture, pushing into the background the well known postural responses of the mesencephalic cat.

Of course, inhibition of diencephalic activity is observed only if the cerebellar stimulation is timed to occur during an outburst of sham rage; and

then a complete suppression of the infuriated behaviour is seldom observed, but a clear decrease of manifestations of anger, in both somatic and autonomic spheres, is quite a common observation. The outbursts of sham rage are, instead, enormously increased during the rebound period. Of course, the rebound facilitating responses are much more striking, if the stimulation is timed to occur during an interval of placidity. Then no response is observed during the stimulation, but a typical outburst of sham rage is evoked by the rebound response. Of course, it is quite easy to provoke manifestations of anger with sensory stimulations of any kind, but the appearance of sham rage just at, and only at, the very end of the stimulation is a peculiar characteristic, so far as I know, of cerebellar responses.

Curiously enough, the best responses have not been obtained by stimulating the anterior lobe, but the faradization of midline structures behind the *fissura prima*, chiefly in the region of Ingvar's *Lobulus Medius Medianus*, has proved to be more effective. The cerebellar nature of these responses is proved: 1. by their typical diphasic character; 2. by the fact that the cerebellar threshold is lower than for motor cortex; and 3. by the observation of silent areas only 2 mm before or behind strongly active spots." (pp. 85-86)

This biphasic characteristic of cerebellar functioning has a number of implications for a variety of physiological and behavioral functions where wide swings of *hypo* and *hyper* excitability are observed. Specifically, such events could lead to excessive inhibition of cardiovascular and respiratory functions with death as the ultimate consequence. Such a possibility has been previously suggested by this writer as a mechanism underlying the sudden infant death syndrome [269].

Fulton [240] described the importance of the study of Nulsen, et al. [270] which reported upon the importance of *frequency* of cerebellar

stimulation in producing inhibitory or facilitatory effects upon motor activity (knee jerk):

"In dog, monkey, and chimpanzee it was disclosed that increasing frequency of cerebellar stimulation caused facilitation rather than inhibition of a cortically induced contraction. The distribution of such facilitatory foci was identical with that of the inhibitory obtained at low frequencies. Inhibition and facilitation could thus be obtained from identical points depending upon the rate at which the point was stimulated. (Below 100 Hz: Inhibition; Above 180 Hz: Facilitation) Nulsen and his collaborators then asked themselves whether this meant that identical pathways were giving opposed effects in accordance with their rate of discharge, or whether there might be two channels of outflow from the cerebellum, one of which would give inhibition, the other facilitation.

To answer this question they sought to destroy individual channels of egress from the cerebellum. When the dentate nucleus was destroyed, particularly its dorsomedial portion, it was found that only facilitation could then be obtained from the anterior cerebellum irrespective of the rate at which a given focus was stimulated. Thus they concluded that the dentate nuclei were primarily responsible for conducting inhibitory effects from the anterior cerebellum. In keeping with this they found that direct stimulation of the uninjured dentate nucleus evoked pure inhibition at all frequencies.

They observed furthermore that when the fastigial nuclei were destroyed, only inhibition could be obtained at all frequencies; similarly, when the uninjured fastigial nuclei were stimulated, facilitation was obtained at all frequencies. In tracing these effects through the cerebellar peduncles and into the brain stem they found that both facilitation and inhibition are mediated through

the bulbar reticular formation, the inhibitory effects passing to the suppressor region of the reticular formation as defined by Magoun and Rhines, the excitatory effects being mediated by its facilitatory areas.

Nulsen points out that the same cerebellar focus which receives a tactile stimulus from a localized cutaneous area will upon electrical stimulation modify motor activity in the same region of the body. Depending upon the frequency of stimulus, either inhibition or facilitation can be evoked from the given focus. The evidence would suggest that the pathways for the two effects diverge and travel through different cerebellar nuclei to the suppressor and facilitatory areas of the reticular formation. (pp. 126-128)

This classic study of Nulsen, et al. [270] has assumed greater significance in the context of the studies of Cooper and Snider [271] that low frequency stimulation (8-12 H<sub>2</sub>) of the cerebellum inhibits seizure discharges in monkey and man whereas high frequency stimulation (100-300 H<sub>2</sub>) facilitates the abnormal seizures. These issues are far from resolved, however, and Cooper, et al. [231] should be consulted for additional information.

Ball, et al. [272] also reported that cerebellar stimulation produced a variety of behaviors that are seen in the isolation reared animal, e.g. compulsive biting (self-mutilation in the isolate); compulsive licking of forepaws and hindpaws (compulsive oral-genital and toe stimulation in the isolate); and stereotypical circling behaviors seen also in the isolate [274]. Berntson, et al. [273] have also reported complex social behaviors (eating and grooming) consequent to cerebellar stimulation in the cat.

It should be noted that virtually all studies of cerebellar stimulation and lesions which produced marked changes in social-emotional behaviors involved primarily midline (paleo) cerebellar structures with little or no effects when lateral

(neo) cerebellar structures were studied. Thus, it would appear that the fastigial nuclei-paleo cerebellar complex is of greater significance for these kinds of behaviors than the dentate nuclei-neo cerebellar complex which would appear to be more related to language and cognitive behaviors. These recent findings amply support this writer's earlier proposal that the cerebellum is involved in complex social-emotional behaviors; that it may well serve as a master regulatory mechanism for sensory-emotional and motor processes; and that it is intimately involved in many of the behavioral and emotional abnormalities of isolation reared animals including disorders of habituation; and in infants and children deprived of somesthetic and vestibular stimulation [35].

A case for an increasing role of the cerebellum in the behaviors of the blind seems plausible. The study of Blass, et al. [275] which demonstrated that congenitally blind subjects with a prevalence of finger-to-hand movements showed significantly greater language skill at encoding complex sentences which portray descriptions of patterned interrelationships among experiences is supportive of this possibility. Their finding that congenitally blind subjects who have a predominance of continuous body touching (touching other parts of the body as objects) exhibited less skillful language products is of considerable theoretical interest within the context of sensory deprivation and stimuli-seeking behaviors as manifestations of dysfunctional states. These authors argue that there is a central role of motor activity in ongoing thought construction and that body movement is a necessary pre-condition for linguistic representation in the blind. The precise role that the cerebellum may have in these processes, particularly for the blind, has yet to be determined.

In concluding this review it would be remiss not to draw the reader's attention to the theories of Bovard [276, 277] which are conceptually very similar to this writer's theoretical orientation.

The above brief outline of the role of the cerebellum in the

processing of sensory information [103; 119], particularly, somatosensory afferents [278]; its influences upon autonomic functions [279]; its interactions with limbic system structures [241; 247-251; 280]; its classic role in the initiation and regulation of motor functions [281, 282; 125, 126]; and its relationship to cerebral mechanisms [283; 125]; its developmental immaturity [209, 210]; and its relationship to problems in clinical medicine [239] has, hopefully, provided a basis for implicating cerebellar mechanisms in a wide variety of developmental behaviors, heretofore not recognized. The suggestion that the cerebellum may be a master regulatory system for sensory-emotional-motor processes [35, 36; 58] is not too far removed from Eccles, et al. [222] conception of the cerebellum as a neuronal machine:

"The immense computational machinery of the cerebellum with a neuronal population that may exceed that of the rest of the nervous system gives rise to the concept that the cerebellar cortex is not simply a fixed computing device, but that it contains in its structure the neuronal connexions developed in relationship to learned skills. We have to envisage that the cerebellum plays a major role in the performance of all skilled actions and hence that it can learn from experience so that its performance to any given input is conditioned by this 'remembered experience.' As yet, of course, we have no knowledge of the structural and functional changes that form the basis of this learned response." (p. 314)

"In attempting to gain insight into the way in which its neuronal structure can function as a computing machine it is essential to be guided by the insights that can be achieved by communication theorists and cyberneticists who have devoted themselves to a detailed study of cerebellar structure and function. We are confident that the enlightened discourse between such theorists on the one hand and neurobiologists on the other will lead to the development of revolutionary hypotheses of the way in which the cerebellum functions as a neuronal machine; and it can be predicted that these hypotheses will lead to revolutionary developments in experimental investigation." (p. 315)

In addition to communication theory, cybernetics and neurobiology, it would seem timely and appropriate to add developmental psychology and that, hopefully, this addition will contribute to the "revolutionary developments in experimental investigation," which will be necessary if human behavior and its phylogenetic and ontogenetic antecedents are to be understood.

It is to these ends that these efforts will contribute to the realization of Fulton's [240] perceptive insight that:

"Motor skills, however, do not make the man, for there is a great reservoir of function concerned with the emotional life of human beings which, little by little, is being brought into the sphere of physiological analysis." (p. 130)

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Discussant: Dr. Paul Bach-y-Rita\*

I will not comment at length on Dr. Prescott's presentation. He and I have agreed that I should instead, expand the discussion to present an example of some of the other functional capabilities of the somatosensory system.

## SOMATOSENSORY CAPABILITY

My subject is the capability of the skin to carry *visual information*. I will discuss this in the light of the question: what is the somatosensory system capable of beyond what we usually ask it to undertake? Our studies have revolved principally around a tactile vision substitution system.

### THE TACTILE VISION SUBSTITUTION SYSTEM (TVSS)

The vibrotactile TVSS consists of a TV camera, a commutator, and 400 vibrotactile stimulators one-half inch apart in a 20 x 20 array, placed against the skin of the back. Blind and sighted subjects manipulating the camera are first taught to recognize lines and geometric forms.

The electrical TVSS consists of a small TV camera mounted on the frame of a pair of glasses which delivers an image to the skin of the abdomen of the blind subject (Fig. 28). After approximately one hour of this training they begin to learn to identify objects, faces, letters, and various combinations of these. Thus, after approximately

10 to 50 hours of training, blind subjects are able to identify accurately several objects placed on a table, to determine the distance between each object, and to locate them accurately spatially, utilizing



Figure 28. Electrical Stimulation Vision Substitution System. TV camera is mounted on glasses frame; batteries are in bandolier arrangement on vest. Subject controls video level and intensity of stimulus. Matrix of stimulators (under shirt) held against skin of abdomen. (From *Brain Mechanisms in Sensory Substitution*, Academic Press, New York, 1972.)

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"visual" cues such as monocular cues of depth, linear perspective, parallax and size constancy. They identify faces from distinctive characteristics such as length of hair and presence or absence of glasses, and can determine motion, such as describing which leg is being crossed. With training, they subjectively locate the stimuli as originating in the three-dimensional space in front of the camera instead of on the back.

We have previously published the details of the instrumentation (Collins, 1970; Collins and Bach-y-Rita, 1972) and of the results obtained (Bach-y-Rita, Collins, Saunders, White and Scadden, 1969; White, Saunders, Scadden, Bach-y-Rita and Collins, 1970). The theoretical foundations have been discussed elsewhere (Bach-y-Rita, 1967; Bach-y-Rita, 1971; Bach-y-Rita, 1972).

In vision substitution, what we have been doing is to deliver the image from a camera to the skin in as many points as we can. At present, the largest system we have tested is 400 points, which is a 20 x 20 array. We have in development a 1,024-point system which delivers a much higher resolution image. We have been training blind subjects, most of them early blinded, in the use of this tactual system of perception. I will, by the way, try to avoid using the term "congenital blindness" although I must admit that I also am guilty of using the word "congenitally" blind when I really mean early blind.

Most of the subjects we have used are college age. We have chosen these for a number of reasons: they are well-adapted, verbose, intelligent subjects, and to avoid any emotional attachment we pay them as they or their sighted classmates would be paid for any other psychology experiments. We start the training with a very simple kind of input such as lines and geometric forms in varying positions. Then we go on to simple objects, more complex objects, three-dimensional arrangement of objects, spatial arrangements in the room, the transitions being as fast as the subject's ability to progress. In some cases, we progress to complex tasks such as the interpretation of faces, for instance. We have had a model in

front of the camera; the subject has identified the model from among the lab personnel, and described her movements.

For instance, a subject might say, "That is Betty, with her hair down," inferring this from the amount of neck visible, "and she is opening and closing her mouth," or "she is bringing her hand from her side over her head." They can do this, but not as quickly as we would, so when I mention tasks of which the blind subjects are capable, it does not mean that it is in real time as far as we are concerned. In other words, it is not at all in the category of being able to interpret the rate of approach of a car.

Our newest version of the vision substitution system uses a miniaturized head-mounted television camera and an array of electrical stimulators on the abdomen. There are no moving parts at all; we use brief pulses of electricity instead of vibrators. We have enlarged on Gibson's (1968) studies and have been able to find very effective pain-free electrical stimulation (Saunders and Collins, 1971).

If we use about 20- to 120-microsecond pulses, then we have a very large window between touch sensation and pain. In fact, we have about 12 levels of gray in the newest system, whereas it is strictly on-off with the vibrotactile system.

We have shown that subjects can use visual means of analysis. I will not use the word "seeing," as it is a touchy word, but the subjects do react to three-dimensional spatial information at a distance and use cues similar to those that we use in vision (but it should be kept in mind that the low resolution and small visual angle make our primitive system capable of transmitting relatively limited visual information). For instance, those who were born blind or became blind very early in life and have no experience of sight, certainly none with visual form, can use such visual techniques as perspective, parallax, looming and zooming. They can tell the approach or recession of an object by its apparent change in size: a basketball that appears to be a certain size we judge

to be so many feet away from our experience, because we know its real size. If it gets larger, we judge it as approaching, and we can even judge its speed of approach. This is something that is absent in the perceptual world of a blind person. There is nothing, other than sound cues, that indicates approach or recession. Yet he can learn looming and zooming very quickly, within a few trials (although we have never tried to throw a basketball towards the camera, due largely to the equipment limitations), and he can generalize from it. We can even get defense-type reactions from pushing the zoom button.

With the 32-line system (1,024-points), which is now partially constructed, we can get much better images. Figure 29 is a visual equivalent photographed from an oscilloscope, but we get even more visual information than this in a dynamic sense. With the various models of the TVSS system, the blind person is not getting a single static presentation. He is getting a dynamic moving

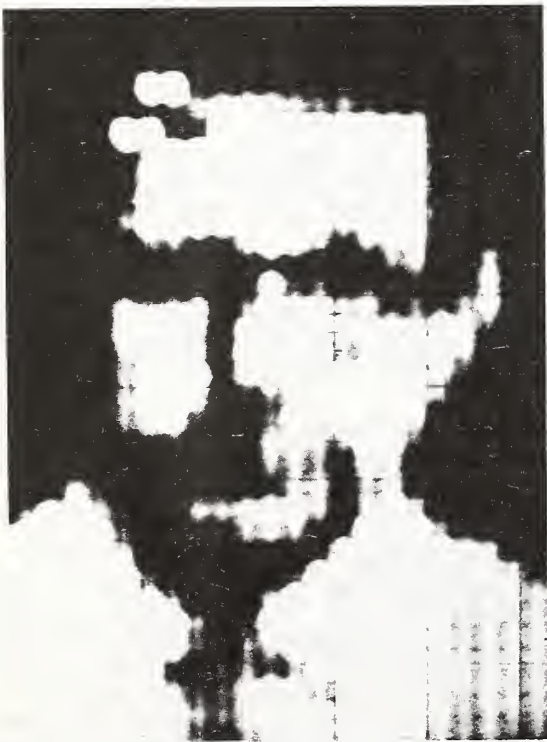


Figure 29. Image captured by a 1024-point miniature TV camera photographed from oscilloscope display.

presentation such as you would get from a television set. In fact, this resolution of 32 lines is about what television was in the early 1930's. We are looking forward to the opportunity to train blind subjects with this system.

## TRAINING SUBJECTS

By means of the position sensors on the camera, we can analyze what each subject is doing; how he moves a camera across the object to be studied. We find that, initially, he is using purely tactile modes of information gathering, in other words purely sequential. He follows the edges around with his hands, and when he gets the camera, that is exactly what he is doing. He is following the edges. As he becomes more and more experienced, he is getting more and more information simultaneously. This is really where vision and the tactile sense differ greatly. If we are going to make a vision substitution system a success, we have to teach the subject to use simultaneous information-gathering modes through the skin. Recent studies (Loomis, in preparation) have demonstrated the development of this capacity with the TVSS.

Eventually we can present objects "tachystoscopically" and the subject can recognize them, either letters or certain objects. Tachystoscopic presentation in this context does not mean milliseconds. It means a second at least. It does mean without moving, so that he cannot be using contour analysis if he is making a tachystoscopic identification.

For instance, Fig. 30 illustrates how one subject examined this object. The scan paths were recorded from position sensors placed in the camera mounts, with the hand-held camera suspended from an overhead boom. The broken line represents camera movement to bring the object into view. The examination is essentially around a contour using what amounts to a contour analysis. As the objects are part of a random presentation of a number of different objects, the subject does not know what is coming, and does not know at what zoom presentation. You can see that it is the same object at two different settings. The



Figure 30. Scanning technique employed by blind subject to view toy horse presented head-on (A), and at 45-degree angle (B). From *Brain Mechanisms in Sensory Substitution*, Academic Press, New York.

higher zoom with a smaller angle of view showing just the upper right corner is more difficult for him to identify. He uses a lot more movements to make the judgment. The judgment in these cases was correct. Another subject would use very quick sweeping movements, essentially one sweep across it, and also make the correct identification (Bach-y-Rita, 1972).

### Perception Development

With about 10 to 20 hours of practice, the subjects no longer feel the object on the skin during the performance of perceptual tasks. This to us is an extremely important break-through point. It is somewhat hard to judge exactly when it occurs, but the behavior does change. Initially, all the perceptual information is a product of an analysis of what is going on on the skin. The subject thinks, "now it is upper left, moving to lower right, therefore it is such-and-such." With a bit of practice, he refers to the objects out in space, and he feels them out

in space. Unless you ask him how he is perceiving, he will continue to perceive it purely as spatial information. If you ask him, "how do you feel that?" he will say, "on my skin." It is somewhat similar to what would happen if I were to ask any of you who were driving, how you stopped the car at the last stop light. Unless I ask you, the perception of the foot movement from the accelerator to the brake is completely blocked out. It is redundant information. Perceptually it is of no use. If I do ask you, you can mentally go through the process of recreating the movement of your foot from one pedal to the other. It is essentially similar to our inquiries into the mode of perception; behaviorally it is spatial, and the sensation of the stimulation on the skin is blocked out since it is redundant information.

### Transfer of Stimulation Mode

One of the points that we really have demonstrated to date is that the plastic changes are central, not peripheral, or at least minimally peripheral. If we train a subject to perceive with one area of the skin such as the back, and then move the display to the abdomen or thigh, the subject does not have to be retrained. He transfers immediately. In fact, he can transfer from one mode of stimulation to another, from the vibrotactile to the electrical. The electrical stimulation produces no spreading waves along the skin as the vibration does. It uses different groups of receptors. Yet the transfer is immediate. However, this only occurs if the subject has been trained to control the camera. This is essential. The importance of the motor sensory link has been discussed theoretically by a number of workers, Katz in the 1920's (Kreuger, 1970); Held and Hein (1967) more recently. It shows up very clearly in our studies.

Subject control of the camera, either by his hand movements or even indirectly by cranks, as in our crude first system, or by head movements when the camera is mounted on the frame of a pair of glasses, allows perception to be exteriorized. If the camera is on the glasses, the

neck muscles control the movements, which is a natural situation for vision, and this allows much quicker perception and perceptual judgments (it also frees the hands, which is, of course, a big advantage). If the subject has control of the camera, it makes no difference where you put the matrix, within certain limitations. Certain areas have high density of innervation, and of course, it is harder to mold it around a thigh than it is around an abdomen.

We use the abdomen because it turns out to be the most convenient and produces the best and fastest perceptual judgments.

The skin and the retina are very similar in many ways. They are two-dimensional receptor surfaces. They use information in two dimensions of space and one of time. They both have lateral inhibitory interactions. Thus, information can be displayed on the skin just as it is captured by the TV camera, without "processing" it, except to reduce it to a display of discrete dots, comparable to the way a newspaper photograph is composed of an assembly of dots.

## APPLICATIONS

The system, as we have been studying it, is considered by us primarily as an education tool. We will be working next on its applications to vocational rehabilitation, and only in a more distant future on the mobility aspect. In education and even in vocational applications, we do not have to make immediate judgments. In addition, we can control the amount of spurious information. I am using "spurious" advisedly here because the real environment contains much information that the subject has to learn to block out. With the very low-resolution systems that we have up to the present, the task becomes more and more difficult if we clutter the environment with a lot of information. In education we do not have to do that, for instance, in teaching a child the concepts of spatial organization of an object, perspective, parallax, or the fact that a rectangular table is never seen by us as a rectangle unless we are looking at it from directly above.

It is a great revelation to the subjects to learn that the table is viewed in perspective; or that a coin becomes elliptical when viewed from an angle, yet we perceive it as a coin, and therefore disc-shaped, or how a corner of a room is formed. These initially are very novel bits of information to these blind subjects. In fact, one of the very bright, bubbly girl students we had, turned after about half an hour of this kind of input and said, "My, you sighted people certainly live in a distorted world."

The strange part is that this degraded the value of vision, at least initially. It seemed to her much less ideal than she had imagined it would be. With a bit more practice, of course, this was overcome. In fact, we are not sure as yet how important training with the vision substitution system has been to our subjects. They come with canes or guide dogs and leave the same way, undergoing a few hours a week of training, so in a practical sense, the system is only of potential usefulness. We have made every effort to avoid any emotional dependence on it, because we just do not have a sufficient number of systems to let anyone keep one for more than a few hours in the laboratory.

This girl, for instance, did report that it has greatly improved her concept of road intersections, and had made it easier for her to travel. We have a few such reports. Until the subject can ambulate with the system or use it in everyday tasks, we will not be able to answer the question of its practical usefulness. Perceptual experience obtained with it is extremely interesting for certain persons such as the psychology graduate student who, previous to becoming involved with the project, had taught a beginning psychology course and had used parallax, perspective, and other concepts of monocular cues of depth, and so on. He had never experienced any of these and within a very short time, he did experience them. This was extremely important to him and has continued to be so because it was part of his professional activity. To most of our blind subjects, this is interesting but not applicable information.

## CENTRAL NERVOUS SYSTEM PLASTICITY

In this discussion, I will ignore the specific receptors or pathways or even most of the central representation. I have covered this area more thoroughly in a monograph (Bach-y-Rita, 1972), which goes into the brain mechanisms of sensory substitution.

The principal point I would like to make is that this is an example and a demonstration of central nervous system plasticity. It is the reason I entered these studies in the first place. My background has been in central sensory physiology. This started as a purely theoretical project on plasticity, and the practical aspects were developed later. The entire project has been undertaken in collaboration with engineer-biophysicist, Carter C. Collins, Ph.D. He has contributed very greatly to this work and all of our studies have been joint studies since 1963.

We have demonstrated plasticity and Prescott demonstrated it in his studies by modifying the behavior that each child is capable of, through training, making it more than it would be without it, producing some changes neurally by interfering with or by manipulating his activity and his behavior. We know this happens in a growing stage in children and animals. What is not clear is that this occurs even very late in life, that plasticity exists into the 60's, 70's, and probably well beyond that. In fact, there are a number of cases--one of them documented in my monograph--of marked plasticity following brain lesions, with years of training, and a great deal of input from the subject himself. This requires a very strong motivation and a lot of feedback, because progress is extremely slow in recovering from a stroke, for example, yet it is possible. There are documented cases with histopathological studies.

So plasticity is not something that is exclusively in the domain of the young. It is a living phenomenon, limited to human study for this discussion. As long as there is life, there exists the capacity to adapt, which is plasticity. There was some

previous comment on the modification at the central nervous system level, the visual cortex, for instance, of plastic changes in perception, and there was the question of increase in thickness of the cortex. Rosenzweig, Bennett and Diamond (1972) have shown that an enriched sensory environment produces a thicker cortex in rats than a deprived environment. Furthermore, such cortical changes are not limited to infant rats, but occur also in adult rats (Riege, 1971). Also, we know that if you bring up rats or monkeys or cats with visual deprivation, the number of binocular cells in the visual cortex diminishes markedly. The reduction in thickness of the cortex of sensory deprived rats, for instance, is very marked. Dendritic spines are essentially absent in sensory deprived animals. There are changes in the number of cells, in the type of cells, in the size of cells. This is dealt with more thoroughly in the monograph (Bach-y-Rita, 1972).

It is clear that there are regressive changes. It is also interesting to note that the most recent evidence from Dews and Wiesel (1970) and from Chow and Stewart (1972), especially the last study, is that some of this can recuperate if the eyes are later opened. I will briefly review these studies: if one eye is closed at birth and later opened two months after birth, that eye never sees properly in this experiment. However, if you force that eye to see by closing the other eye and forcing the animal to use it, and forcing means much manipulation as Chow and Stewart (1972) especially have found out (it means gentling treatment of the animals, it means positive and negative reinforcement). By forcing the animal to use that eye, he does. He really learns to see with that eye, and furthermore, the cortical physiology, the microphysiology of the cortex reveals patterns that are more like normal than those in which this training is not undertaken. So there is a certain amount of recovery possible in a cortex that has been deprived since birth.

A critical question regarding central-nervous-system plasticity concerns the modifiability of the responses of individual cortical neurons during learning. Woody and

Engel (1972) have recently provided some valuable insights into this question. They showed that during classical conditioning of a motor response, more cells in the coronal-precruciate cortex of a cat become involved in producing the conditioned movement than are noted in the absence of conditioning. Microstimulation of cells produced a greater amount of movement at a lower threshold of stimulation than in the absence of conditioning. They concluded that plastic, persistent changes occur as a function of learning. Further, they determined that their studies support the view that the motor cortex in the cat consists of intermingled micro-colonies of different projections, and that mediation of a conditioned reflex may depend, not on a particular pattern of impulses in a few cells over a relatively long time, but rather on the coincidence or near coincidence of one or two spike discharges in each of at least 100 units, within a relatively brief time, perhaps four msec.

I think there has to be a neural correlate to every learning action; for instance, the pianist who undergoes years and years of training to control his fingers, to control the sequences, must have some neural changes. Something like 16 movements a second is the maximum number of finger movements that has been recorded. There is a tremendous amount of pre-planning required for this, and I am sure there is a cortical representation of this, although I know of no relevant studies. To do so in a human would require two interventions, one before and one after training. We do know, especially from the studies at McGill University (Penfield, 1958), that there is a cortical map that is dependent on the amount of input from a particular area. The lips, for example, are a very large sensory area on the cortex. This mapping is based on one-shot recordings, and no one knows if this can be modified.

## INHIBITORY CONTROL

The most important aspect of learning this or any other input, I consider to be centrifugal control, which means brain control of sensory input, and therefore it really is a progressive inhibitory control. In

other words, we inhibit more and more as we learn more and more. This can be seen in studies of children's eye movements as they learn to read (Nodine and Lang, 1971), and can be seen in animal studies. For instance, the sensory deprived dogs described by Melzak and Burns (1964) were kept in isolation for several months and then brought out. The major observation was not that they could not respond to stimuli. To the contrary, they responded to every stimulus. They could not select from among the stimuli. This I consider to be the critical aspect of learning.

Similarly, those blind persons who have achieved sight late in life through surgery, in studies reported by Valvo (1971), by Gregory and Wallace (1963) and by von Senden (1960). In these cases, some of the acuity measurements are fairly good, but what happens is that the subject cannot choose among the many sensory inputs and he is reluctant to use vision. It is a painful input and very depressing. Some of these subjects have wound up committing suicide or becoming very deeply depressed. I would consider this to be largely due to the absence of centrifugal control and the ability to inhibit the input, though of course, other factors, both psychological and neurological, are also of importance.

We cannot only learn to inhibit sensory input, but we can change it at will. When looking at a face, without moving my eyes I can shift my attention to the background or the foreground or to something slightly to one side or the other strictly by a change in selective input. This to me is the principal aspect of what we are doing in sensory substitution, and of what much of learning consists.

Prescott has emphasized the importance of the somatosensory system in behavior, and I have discussed its capacity to transmit information. Ultimately, however, it is the central nervous system which translates the input from the skin into useful information, into perception, and into behavior. It is these functions that are reflected in the remainder of this symposium.

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Discussant: Dr. Gershon Berkson

In addition to commenting briefly on Dr. Prescott's paper I would like to describe some studies of stereotyped movements which result from maternal separation in subhuman primates.

### SOMATOSENSORY MECHANISMS

Anyone who has tried to take an infant monkey away from its mother during the first week of life knows that somatosensory mechanisms underlying reflexes which maintain proximity to the mother are very active at that time. The infant grasps tightly to its mother's fur, screeches while being removed and stops screeching when he is returned to her. Whether somatosensory mechanisms are important in early development is therefore not as much in question as how they work and what happens when the infant is forced to develop without its mother.

Literature on the neurophysiology of animal social development is sparse, and Dr. Prescott has summarized what there is of it very well. A good deal more is known about the effects of isolation-rearing. As Dr. Prescott has indicated, one of its general and enduring effects in higher primates is the development of stereotyped behaviors which are generally not seen in the behavior of normally reared animals. These behaviors include primarily body-rocking and abnormal hand movements, although eye poking and head-banging also occur.

### STEREOTYPED BEHAVIORS IN HUMANS

Interest in these behaviors comes partly from the fact that similar ones are seen in blind, autistic and mentally retarded children and are pathognomonic at certain ages.

It is likely that the factors which control development of the various stereotyped behaviors are different so that they need independent analysis. Most is known about body-rocking.

### Moment-to-Moment Changes in Body-Rocking

Two concepts have generally been applied to explain how body-rocking is maintained. The first is that it is an expression of high energy or activity level; the second that the individual who rocks in a repetitive manner is stimulating himself. At first sight these ideas are plausible. However, they are difficult to put into operational terms and have not proved to be heuristic.

Another approach has been to describe those characteristics of the environment and the individual which modify the expression of body-rocking. It looks now as if factors which increase general arousal level also increase body-rocking and those which evoke other behaviors will tend to decrease its expression. It has also been shown that drug and reinforcement therapies altering arousal and alternative activities can reduce rocking.

### Etiological Factors

Although reduction in the expression of body-rocking from moment to moment is of interest, preventing its chronic expression is also desirable. Dr. Prescott has described to you the experiment by Mason and Berkson in which it was shown that isolation rearing on moving dummy-mothers prevented the development of body-rocking. This suggests that the manifestation of body-rocking in most normal infants in our society might be related to the fact that they are not regularly carried around on their mother's hip. It also suggests that body-rocking of

populations who are at risk for stereotyped movements (such as the blind retarded) might benefit from carefully programmed rearing with movement stimulation, at low arousal levels, with opportunities to interact with the environment maximized. That such an approach might be effective even

with blind children is made plausible by recent studies which suggest that body-rocking develops in blind monkeys only if they are socially isolated: that is, blindness does not appear to be a sufficient condition for the development of stereotyped movements.

## General Discussion

### IQ AND TVSS

Dr. Friedlander asked whether enough blind subjects of a sufficient range of intelligence had been tested to know whether there was any relationship between IQ and the amount of practice required to master the use of the TVSS. Dr. Bach-y-Rita replied that some preliminary tests had been made and did not show a correlation. However, most of the subjects had fairly high IQ's. There were studies being done with children at the Overbrook School for the Blind in Philadelphia currently. It would take some time for results to emerge. At present they found that the older the child, the faster the development, but then again the smaller children do not fit well on the fibrotactile system they had, so that an 8-year-old may contact only a quarter of the total number of points in the chair. These studies had to be done under better conditions. His team was working on a garment, essentially a girdle, to hold the contact. When they were looking around for technical assistance in this regard, they found that the only persons who had experience with long term maintenance of foreign material in contact with skin were the girdle manufacturers. Work on this modification of the device was quite advanced.

### CENTRAL NERVOUS SYSTEM PLASTICITY

Dr. Prescott recalled Dr. Bach-y-Rita's statement that the role of the

cortical inhibitory mechanisms was very central to the phenomenon of CNS plasticity. He said it perhaps was not surprising that the cerebellar cortex and the output of the cerebellar cortex, the purkinje axon system, was exclusively inhibitory in nature, and this was one of the major inhibitory neural systems of the brain. He felt this was pertinent to the role of inhibition as a regulatory system.

Regarding the possible nature of plasticity Dr. Parmelee commented that it conjures up a different picture in everybody's mind. Some think of new neurons developing, or neurons shifting in position, or new dendrites and new synapses; but the nervous system is highly redundant, and there are many ways of learning the same cognitive structures. Some plasticity may simply be using a redundant system with no particular change in the dendritic mechanism or the synapses, and involve cognitive structure alone.

Dr. Bach-y-Rita agreed this was a very real possibility, which he had not mentioned. However, he urged caution on this point. In a recent article in the *Annual Review of Physiology* (1972, Vol. 34, pp. 315-36) Patrick Wall and Ronald Dubner have argued that the word "redundancy" is used much too lightly, that one is not necessarily asking the right question if one assumes that certain tissue was not necessary. Galambos, Norton and Frommer (*Exper. Neurol.*, 1967, Vol. 18, pp. 8-25) for instance, have shown that in a cat one can destroy 98.5 percent of the optic tract fibers--and

with 1.5 percent of the total number of optic fibers, that cat can perform complex visual tasks after a few weeks of training. One can roll a ball across a crowded room and the cat will run to get it, or he will make visual discriminations. However, that 1.5 percent is uniformly distributed among the visual field and that is one difference between cats and humans. But Wall finds that the cats do not show large scotomas, that they are not cocking their heads in one direction or the other. They do have permanently dilated pupils, and it seems each fiber can cover a large area of retina. In other words, the remaining optic fibers have contact with diffuse retinal cells. Another interesting part of that study is that although when the fibers are destroyed the visual potential initially goes down practically to zero, within three or four weeks it is back to control levels. It seems that the few remaining fibers are then affecting all of the cortical cells that were previously affected by all optic tract fibers, including the destroyed ones. It is a rather complicated study, and could bear repeating. However, many other studies, going back to the Lashley report, show that quite an amount of vision can be accomplished by the animal with just two or three percent of the cortex remaining; although that is another matter.

## HUMAN BRAIN STUDIES

Dr. Parmelee pointed out that to have a function and lose it was different from having it develop. Also, we tend to jump from animal work to human work, but we have to remember that we cannot study the human brain in the same way. To get a good stain so that one can look at the spines and the dendrites, one has to have the material immediately, which requires a biopsy. For the same reason there are few electron microscopic or enzyme studies of developing human brain. So we did not have this information in humans. Dr. Bach-y-Rita replied that we did have it from such sources as follow-ups to brain lesions, for instance, war injuries. There was extensive work on this. This information was available, for instance, in the case

described in his monograph, in which there was a histopathological study following death from a known cause.

## VISION SUBSTITUTION

Going back to the question of the nature of sensory plasticity, Dr. Bach-y-Rita pointed out that sensory substitution was not limited to vision. There were studies of auditory substitution, but they were not as advanced as the vision studies. They were getting very interesting results, and were also extending their work into limb prosthesis and other areas. However, limiting the discussion to vision substitution, he suspected that what was lost in blindness was not, essentially, the capability to see, but the input to the areas with which one sees; because you do not see with the eye, you see with the mind. The idea was to provide a substitute for the lost camera function of the eye. (Actually, the eye has more than just a camera function. There is a centrifugal interaction right at the retina, of which we are aware mostly from animal studies. There are many phenomena that go on at the periphery, so when the eye is lost, you lost more than just a camera. However, for the sake of simplicity, he was taking just that aspect.)

A TV camera is an excellent substitute for providing the visual information. If one could get the information to the brain, then one would see if the substitution did occur. The skin was being used because they felt that the skin, as a healthy sensory system having all of its structures intact, can undertake centrifugal interaction at the periphery or at each stage. Essentially this amounts to asking that system to modify what it is already doing, adding onto what it is doing and giving it another role. The input undoubtedly goes to the sensory motor cortex. This remains to be absolutely demonstrated, but he was reasonably certain this was the case. From there, and from primary cortex, it then goes to other areas which are much harder to define but where there is undoubtedly sensory modality mixing.

Sensory modality identification becomes less critical as we go higher up the perceptual chain. In fact, as J. J. Gibson (*The Senses Considered as Perceptual Systems*, Boston: Houghton, 1966) points out, if you run out of a building yelling "fire" it might take you some time to realize whether you felt it, saw it, touched it, smelled it, in any one of several modalities. The identification of modality is essentially lost for this perception, but it can be traced back, of course.

## MULTIMODALITY OF VISUAL NEURONS

In other words the input through the sensory substitution system undoubtedly goes primarily to the sensory motor cortex. From there, he could not tract its pathway, but suspected that the visual cortex was not greatly involved in its analysis. The visual cortex, however, is not purely visual. In animal studies, if he might be permitted to refer to them again, about 40 percent of primary visual neurons, even those in the primary visual cortex, have been shown to be multimodality. In their own work they had recorded auditory and skin stimulation response from 40 percent of the visual cortex neurons studied (*J. Neuro. Physical.*, 1965, Vol. 28, pp. 1233-9). Those number several thousands. So we know that sensory information gets to other areas besides its primary representation. However, the latency is not quite as short, in fact it is about double the usual latency, and the response is more sensitive to anesthetics. So, the pathways are somewhat different.

Dr. Bach-y-Rita did not consider this as by any means an answer to Dr. Parmelee's question regarding the nature of sensory plasticity which was critical, and he did not see how we could answer it in the near future. There was no way one could record from the human cortex of a subject who had undergone training with a sensory substitution system, so he thought that specific aspect would have to remain speculative. It will be possible to study the development of the evoked potentials, their distribution and maybe the effect on the late components of the evoked potential which seems to be more related to perceptual phenomena, but this is

about as far as we will be able to go.\* Dr. Parmelee commented that the late components may be coming through the nonspecific system; to which Dr. Bach-y-Rita replied these were the pathways that also probably provided the input to areas such as the visual cortex.

## OTHER SENSORY CORTICAL AREAS

Mrs. Adelson asked whether the same kind of multimodality was represented in the other sensory cortical areas, and Dr. Bach-y-Rita explained that it is even more so, because the visual response can be recorded in many places. The visual cortex is always taken as the prototype or the best example of the specific cortex, and yet even this cortex is not that pure. He had been trying to avoid the subject of the nonspecific versus the specific system, but he felt he should pursue it once it had been raised. In his opinion the whole field is totally changing due to Wall's studies. It is becoming very difficult now to speak about specific and nonspecific. The dorsal column system which everyone thought carried the specific information may be primarily responsible for exploratory behavior. Actually, this was rediscovering the wheel, because Sherrington said that in 1900, and there were experiments going back to the 1870's showing that dorsal columns can be sectioned without loss of perception.

Extending this even further, Dr. Prescott suggested that, given the inherent plasticity of the brain we may in fact structure the functional activity of our own brain cells depending upon the nature and the quality of the sensory experiences during the formative periods of development. In that case our brains as individuals

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\*Note added in proof: Dr. Bach-y-Rita reports having obtained clear proof of somatosensory evoked potential differences between normal sighted subjects and tactually trained blind subjects (M. Feinsod, P. Bach-y-Rita, and J. M. Madey, "Somatosensory evoked responses--Latency differences in blind and sighted persons." *Brain Research*, 1973, Vol. 60, p. 219-23.)

are really quite different from one another in terms of plasticity, depending upon our early sensory experiences. This was hardly surprising, given the individual differences in behavior, but he felt it did suggest an even further extension of the concepts of plasticity.

## TRANSFERENCE OF AFFECTUAL ASPECTS

Turning to another aspect of sensory substitution, Dr. Bach-y-Rita said that another fascinating question was whether it can ever transfer the affectual aspects. We know that this is hard to obtain in subjects who acquired sight late in life, although these have never been trained properly. We know, and he could confirm from personal experiences, that in the languages learned after the first language there are certain emotional or affectual components that are not present. He had learned Spanish at 8 years old, and spoke it fluently. Yet for him, Spanish curse words never have the same emotional content as in English.

So, there are certain affectual components that perhaps can be produced only at an early stage. For instance, colors. What will colors mean to someone who has not experienced them from early childhood? Will they have the warmth, and the range of emotional connotation? We know that the Valvo, Gregory, and von Senden cases found colors very disappointing, and some of his team's experience with vision substitution was quite comparable. When they were using photographic material for some of their blind subjects--and some of them did quite nicely on a certain range of photographs that had good contrast--they decided to use *Playboy* centerfolds for some of the college students. The two who were chosen to try this were capable of determining the various components, a breast here and a leg there, and what not, but it had no affectual component. They were very disturbed by this, so the experimenters dropped it immediately. Another facet of this was that all of the subjects, after they had become somewhat familiar with the system, would say something like, "gee, can I bring my girlfriend? I would love to see what she looks like" or "can I

look at my guide dog?" Although the research team was trying to keep down the emotional content. It was found that this was universally disappointing. One fellow brought his wife, and pointed the camera at her. He gazed at her for 5 minutes without saying a word, to the increasing discomfort of everyone including the poor wife.

## LONG-TERM USE

Whether this would change with long term experience, Dr. Bach-y-Rita could not say. These were only initial perceptual experiences. If someone were to wear a sensory substitution system around the clock for five years, for instance, between the ages of 15 and 20, which would certainly make it a late development, would he then get the affectual components to colors, to shapes, and so on? They were now beginning to work with children. For the present with eight-year olds and nine-year olds at best, but hopefully later one could start even in the cradle. The results could be very different under those conditions. These were things that only the future could determine. In fact, he had to point out and emphasize that he could only be firm about the results obtained with 400 points. One could not tell what would happen with 1,000 or 4,000 points, which was what their next systems would be. In fact, he did not even know if it could be handled by the skin. So anything beyond the 400 point studies, which were what he was reporting on, had to be in the realm of speculation.

## Fourth Session

### SELF-REPRESENTATION IN YOUNG BLIND CHILDREN\*

Formal Presentation: Selma Fraiberg and Edna Adelson\*\*

It is known that among children blind from birth there is a delay in the acquisition of "I" as a stable pronoun. In our longitudinal studies of the early ego development of children blind from birth, we have been able to examine the evolution and the vicissitudes of self-object pronouns and self-representation in language, play, and imagination.

#### GROUP STUDY

Thirteen children who have qualified for Group I in our longitudinal studies have been followed since the first year of life. All have been totally blind from birth or have light perception only. They have no other sensory or motor handicaps and are neurologically intact. All of these children have received educational guidance through our program.

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\*\*Child Development Project, Department of Psychiatry, University of Michigan Medical Center, Ann Arbor, Michigan.

Our sample, then, is a highly selected one and our findings cannot be generalized to the larger blind-child population. In a typical blind-child population there will be children with other handicaps, children with some degree of useful vision and children who have been blinded post-natally. Our children are, then, advantaged in a blind-child population by the intactness of other systems and advantaged, too, by a program of infant education which has facilitated their development. They are disadvantaged in a blind-child population by total or near total blindness and blindness from birth.

#### "I" CONCEPT

The first babies of our longitudinal study have now moved into the preschool or school years. Four of these children have given us an extraordinary opportunity to follow the course of development which leads to self-object representation and to the acquisition of the concept "I." Among the four children we have seen a protracted evolution of self-reference pronouns, a delay in the achievement of "I" and "you" as grammatically correct forms. Long after "I" entered the vocabulary of these children, pronoun reversals and semantic error testified to the difficulties in achieving a concept of "I" in which the self could be taken as an object.

Normative data which can give us fair comparisons are not available for

sighted children. Gesell includes personal pronoun usage in his scale, using parent reports, and places the item "I" at age 2:6. (No other standard developmental scale for children under three includes this item.) However, Gesell's scoring and his reliance on parent reports cannot distinguish for linguistic study the syncretic "I" imbedded in verb forms of need or want (e.g. "ahwanna") and the "I" which is disengaged from this early set and is used inventively in new combinations. The two levels of "I" represent two levels of self-representation, and the second "I," which is freed from syncretic forms, requires a high level of inference.

Among the blind children in our sample who have been available for continued study between the ages of two and six, the age of emergence of the *syncretic* "I" does not distinguish them from sighted children. It appears in the range two to two and one-half in a pattern similar to that of sighted children. But the "I" which is liberated from syncretic usage, the "I" as a stable grammatical form which is used consistently for self-reference, appears in an age range that distinguishes the blind preschool child from the sighted child. Using the criteria "correct usage of I" and "I used inventively in new combinations," the age range for four children is as follows:

|        |                                     |
|--------|-------------------------------------|
| Karen  | 2:11                                |
| Paul   | 3:6                                 |
| Kathie | 4:10                                |
| Jackie | --- (has not appeared at six years) |

The two children who achieved "I" between the ages of 2:11 and 3:6 had light perception which we have reason to believe is to the advantage of the blind child, even when he cannot perceive forms. Both Kathie and Jackie are totally blind. Jackie shows many signs of pathological development (although he is neurologically intact). The age of achievement of "I" is not, in itself, a measure of language achievement. An assessment of vocabulary and syntax at age two and one-half would place the four children in the following order: Paul (1), Kathie (2), Karen (3), Jackie (4). The two highest ranking children, Paul and Kathie, achieved "I" at the

ages of 3:6 and 4:10 respectively. The correspondence between the achievement of "I" for consistent self-reference and concurrent self-representation in play was demonstrated in the protocols of each of the three children who achieved "I" as a stable form.

## PROBLEMS OF SELF-REPRESENTATION

In order to examine in some detail the blind child's extraordinary problems of self-representation in language and play, I have chosen one of these children, Kathie, for illustration.

Kathie has been followed by us since nine months of age and is now six years old. She is totally blind. Kathie was three months premature. The diagnosis, retrolental fibroplasia, was made at five months of age. She is a healthy, very bright child with no other sensory defects and is neurologically intact.

Kathie is the youngest of five siblings. Her parents have shown extraordinary ability to intuit a blind child's experience and every help that parents and our staff specialists could give has been available to promote the fullest use of her good capacities.

Now, at six years of age, she has excellent command of language; she is inventive in imaginative play; she is well behaved but also mischievous and fun-loving. She is in the first grade in a classroom for sighted children and holds her own. She has considerable appetite for new experience. She enjoys cooperative play. She is independent in dressing and feeding. She is fully responsible for her own safety in outdoor play.

## KATHIE

The story of Kathie's language and representational intelligence followed a different route from that of the sighted child. In the absence of pictorial memory, the evolving forms of mental representation, the concepts of time and causality, of self-representation and the

construction of a world of permanent objects were all delayed by sighted child norms. Yet, a simple vocabulary count and identification of word and thing or an analysis of phrase and sentence patterns would not have distinguished her speech at the age of two from that of sighted children. Between the ages of two years and four years, the study of Kathie's speech and play gave us a slow-motion picture of the relationship of language to other cognitive processes and the means for identifying those elements in self-object representation which are dependent upon a coherent and intact sensorimotor organization.

### At Age Two

When Kathie was two years, one month old she became the subject of a linguistic study conducted by Eric Lenneberg with our staff. Speech samples were obtained in home visits and Dr. Lenneberg and Nancy Stein of our staff worked out a dictionary: "What does Kathie *mean* when she *says*. . . ." Following a three-month study, Dr. Lenneberg felt that Kathie's language competence compared favorably with that of the sighted child of the same age. Her vocabulary at that time was well within the range for sighted children. She correctly identified members of her family and a number of people outside of the family. She identified by touch or sound and named all the objects in her home with which she had contact. She quickly learned the names of novel objects brought by us. She had four- or five-word phrases in which present tense verb forms were imbedded, but not yet used inventively in new combinations.

She could express her wishes in phrases. Here are a few samples: "Wanna hear a record," "Wanna go walkie," "Wanna go lie down," "Wanna hear music," "Want to feel, . . . What's that?" (confronted with a novel object).

She had a range of useful words for the expression of affective experience. "Feels good!" "Tastes good." And the dictionary records that she used the words "damn" and "shit" when she was angry.

She employed parental admonitions to inhibit forbidden actions. "Don't put your finger in your eye," she said to herself, imitating her mother's voice when she pressed her eye, and sometimes succeeded in inhibiting the act. "Hot!" she said, to warn herself when near the stove.

There were examples of generalization in our records. At Christmas time, when we brought her a toy-sized Christmas tree, she explored its plastic bristles thoughtfully and said, "Feels like a brush!" She could identify a chair and name it, and generalize from chair to chair.

We heard pronoun reversal and pronoun confusion in nearly all the speech samples we have during this period. When she touched the hair of one of the observers, she said, "My hair," using the wrong pronoun. "Want me carry you?" she said to her mother when she meant that she wanted her mother to carry her. The pronoun "I" was rarely used and, typically, appeared as a syncretic form "Ahwanna" or as an "I," "You" reversal.

However, the pronoun reversals and the unstable use of "I" do not distinguish Kathie at two from *sighted* children of the same age.

In Dr. Lenneberg's unpublished notes, he records one item which puzzled him. "All attempts to make her listen to short stories (while sitting on laps and being quiet) have failed." In a summary statement, he draws attention to the disinterest in stories as being one factor that points to "a somewhat different language beginning from that found in sighted children." As it turns out (in retrospect), this puzzle was already one of the clues to certain incapacities in symbolic representation which were later to be of considerable interest in our study of blind children.

Dr. Lenneberg moved to Cornell and had no opportunity to follow Kathie's language development beyond the age of two years, three months. When I now report further developments in Kathie's language history, we will find much that interests us from a developmental point of view but we will also miss much that Dr. Lenneberg

would have brought us from linguistics.

### At Age Two and One Half to Three

Between the ages of two and one half and three, we became aware that Kathie's language and her capacity to represent showed marked deviations from that of the sighted child. In both our detailed home observations and in the reports of the mother, it was very clear that Kathie could not represent herself through a doll or toy. She could not recreate or invent a situation in play. She could not attend to a story or answer questions regarding a story or tell a story herself. She could not spontaneously report an experience. We have no instance in our records at three in which she used the past tense in speech. And still, between the ages of three and four, she continued to confuse and reverse pronouns and the concept of "I" had not emerged as a stable grammatical form.

To illustrate the problem, I now propose to present some of our own observations of Kathie at the age of three. In a later section, I will bring in observations at four years of age.

### At Age Three

When Kathie was three years, twenty-three days, Edna Adelson and I arranged for her to visit us in our nursery. The nursery visits had been a special treat for Kathie in preceding months. Since we already knew from home observations that Kathie could not invent in play or represent herself in play, we sketched an observational plan and procedures which would tell us more precisely where the incapacities lay and what her limits might be.

### Experimental Play Situations

I worked out a group of experimental play situations which would permit us to compare a blind child's capacity to represent in play with that of a sighted child. I was satisfied that the "pretend" games I had in mind could be played with any sighted child between the ages of eighteen months and two years, giving

much leeway for three-year old Kathie.

The observational plan included both structured play situations and unstructured periods to capture spontaneous play. In order not to strain Kathie's tolerance, we moved freely between the structured play periods and the unstructured "free play intervals." In the one-hour observational period which was recorded verbatim and documented on 16mm film, the structured portions of the observation totaled 20 minutes. This gave us a balance between the two modes of observation which favored the spontaneous productions and would permit us to assess fairly Kathie's play capacities and language. Kathie's mother was present throughout.

When I now present material from this play session at three years of age, it is important to keep in mind that we already knew Kathie's play incapacities from naturalistic observations in her home, and that the purpose of the structured play observations was to get more precise information regarding the level of symbolic representation available to this bright, three-year-old blind child. When I pursued certain elements in play, though it was clear that Kathie could not follow me, it was because we needed the negative demonstration as much as the positive demonstration both for this period of observation and for our projected retest at four years.

I was not a familiar person to Kathie and gave her a good deal of time to greet her old friends at the Project to get her accustomed to my voice and to begin some verbal exchanges. When I felt that she was at ease with me and she came close to me at the work table, I gave her a hint that there was something on it. She came over, sniffed, and said, pleasantly surprised, "Play dough." I waited to see what she would do. She squeezed it, handled it, put it down. When I saw that she would not invent with the play dough, I suggested we make a cookie and guided her hands with the cookie cutter. She was interested but did not extend the possibilities. Later, to test her notions of "pretend," I asked, "Can I have a bite of the cookie, Kathie?" Kathie, clearly confused but amiable, said, "You have a bite!"

and put it in her mouth. Kathie said, reflectively, "This cookie different."

Because of the confusion in "me" and "you" elicited in this sequence, I used an occasion later to test facial analogies. I asked, "Where is my mouth, Kathie?" There was no response to "my mouth" but her hand moved to *her* mouth. I: "Where is my nose?" She made no effort. (Neither Edna Adelson nor Kathie's mother had been able to get Kathie to correctly name parts on their faces if they used the pronoun "My" [i.e. in the question, "Where is my nose?"]. If Kathie's mother asked "Where is *Mommy's* nose?" she could "respond correctly.")

Knowing how much Kathie loved her own bath at home, I had sketched out a sequence for doll play. There was a basin of water, a doll, a towel. I brought over one of our dolls and suggested we give the dolly a bath. (We knew, however, that Kathie had no interest in her dolls at home.) I introduced the doll to Kathie, who gave it a few cursory touches and was clearly not interested. I tried to elicit interest. "Where is the dolly's mouth?" -- no answer. "Where is the dolly's nose?" -- no answer. We have not been able to get a demonstration when we have played this game with other blind children of Kathie's age. Clearly, Kathie could not endow the doll with human characteristics.

Kathie made it clear she did not want to give that baby a bath but I was not prepared for a bath that took place within a few moments. As soon as Kathie touched the water, she herself stepped into the tiny tub, giving me only a second to remove her new red shoes. She curled up in the tiny tub, legs folded up, and made joyful screeches. Then followed a series of little chants and songs, her own bathtub songs at home.

After several minutes of splashing and singing, I thought I would take a chance on reintroducing the doll. I suggested we wash the dolly's hair (guiding Kathie's hands to the doll's hair). I even went through a performance in which I, representing the doll, squealed protests and said, "No, no, I don't want a shampoo."

Kathie did not pick up the game but now she did something else.

As Kathie squatted in the tub, pushing herself up and down in the water, she began to carry on a dialogue in two voices: "Swimming in the water" -- "Mama look at that" -- "Whee, whee" -- "Can you feel it?" "Okay, you stay in the water." "Okay, you sit down in the water." Very clearly, one voice in this speech belonged to Kathie and one voice to her mother, bathing Kathie.

Before drawing inferences from this last anecdote, let me give a second set of observations which are very similar.

Later in the session, Kathie was walking around the room when she discovered the sink in the nursery. We did not tell her what it was. She climbed in and examined the sides with her fingers. One of us said, "What is it?" and, after a moment, she said, firmly, "It's a sink!" Now, Kathie curled up inside it. She was unmistakably pretending that the sink was a bed and said, in a mother's intonation, "Night-night, have good sleep, night-night." "Go sleep in the sink." She closed her eyes, then opened them mischievously, and went through the whole routine again, with some variation. "Right here." "You be a good girl!" Once I tried to extend the game by saying, "Good morning, Kathie!" Kathie, not to be distracted, said, "See you in the morning, good night. Then go in pool." (Echo phrases--apparently her schedule for summer.)

Obviously, then, Kathie could "pretend" when she herself was the subject. Could she pretend now with a doll? I doubted it but I brought over the doll for an experimental demonstration. I said, "The dolly wants to go to sleep. Let's put the dolly to bed." I gave the doll to Kathie. Without any ceremony she dropped the doll over the side of the sink and pursued her own game.

In these last two examples (and others which we have in this and other sessions), it is very clear that Kathie had a form of "pretend" in which she could take herself as object and play "subject and object" in a game. But she could not yet

move beyond to the further objectification (actually *projection*) which would permit her to represent herself through a doll and to represent herself as a mother, to that doll for example.

Note, too, how important it is for her to get *into* the basin, to put herself *into* the sink for "pretend." Where vision would allow her to *imagine* herself in the basin, the sink, etc., and then also to *imagine* her doll as herself in the basin, and the sink, she is obliged "to go through the motions," to transpose through action that which would be transposed through vision. We must remember, of course, that sighted children in nursery school also enjoy fitting themselves into the doll bed or the doll carriage, but at this age they can move flexibly between such ego-centric play to representational play, later placing the doll in the bed and the carriage, etc.

Along with these failures in self-representation, we see throughout this session, even in this condensed form, that "I" and "You" are not yet used correctly, which ties in with observations in which subject and object pronouns are confused in comprehension as in following the directions for the game "Where's my nose?" "Where's your nose?" The pronouns do not yet define subject and object, which may indicate the level of her conceptual development, which does not yet permit her to see herself as an object to others. She is indisputably "Kathie" to herself and to others, and her mother is "Mommy," but she cannot assimilate the semantic ambiguity in which she is a "you" to others and they are a "you" to her. The same ambiguity bedevils her in comprehending "me" and "my" usage in the game "Where's my nose?" etc..., yet we recall that she could correctly identify facial parts by pointing if the questioner used the form "Where is Mommy's nose?" "Where is Mrs. Adelson's nose?" "Where is Kathie's nose?"

From our protocols in this session and home visits during this period (3:1) we do not yet have an example of "me" usage in self-reference.

Typically, when she wanted something she would say, "Give it to her!" in the echo form.

(The first example of "me" in self-reference [not echo or reversal] occurs at 3:6 and the context happens to catch exactly a transition point. Kathie's mother called her in the midst of play. Kathie was clearly annoyed at the interruption. She roared at her mother, "You leave her alone!" Then, shortly afterwards, "Leave *me* alone!")

The question should be raised: "Would Kathie's performance have been more fairly tested if the play sequences had been undertaken by one of her old friends on the staff, or her mother?" To test this possibility, we invited Kathie and her parents to another play session one month later. This time Mrs. Adelson, her old friend, took over some of the play sequences and we also involved the mother in a "Where's my nose?" "Where's your nose?" game. Even under these most favorable circumstances the limits of Kathie's performance remained the same.

Now I would like to suggest that the observations on subject-object in play and the problem of expressing subject and object in language have a unified core in capacity for a certain level of mental representation.

The capacity to represent oneself in play is a measure of the level of conceptual development in which the self can be taken as an object and other objects can be used for symbolic representation of the self (Piaget). Kathie's play incapacities at age three are exactly mirrored in speech in her pronoun reversals and her difficulties in achieving "I" as a stable concept and a stable grammatical form. Yet, this child at the age of three had a rich vocabulary, if we make allowances for the restricted experience of a blind child, and her syntax does not jar the ear until we examine the sentences in which pronoun usage governs order and coherence.

I hope that no one will think Kathie was retarded or in danger of an autistic development. Let me now give you a glimpse of Kathie between the ages of four and five, as Evelyn Atreya and Edna Adelson continued to follow her progress.

## At Age Four to Five

Between the ages of four and five, Kathie began to represent herself in doll-play and, in a parallel development, we now began to see new complexities in syntax, a stabilization of pronoun usage and, finally, the emergence of "I" as a concept and a grammatical form.

At four years, six months, we begin to get observations in doll-play that paralleled in all significant ways, the doll-play of sighted children at ages two to three. Kathie was a solicitous mother to Drowsy and Pierre, her two dolls. She fed Drowsy from a toy nursing bottle (filling it herself and capping it with the nipple). She murmured endearments. To Drowsy: "Want to give me a kiss? Bye-bye, Drowsy." "Did you bump your head?" (rubs it to make it feel better). . . "She's crying. She wants her bottle." She also spanked her dolls in anger and scolded them for misdemeanors. She toilet trained both dolls by placing them on her old potty chair.

Around the same time, Kathie acquired an imaginary companion she called "Zeen." Kathie carried on conversations with Zeen in two voices. When addressed by a friendly adult, Zeen was willing to extend the conversation. At lunch, when the observers were having coffee, Mrs. Adelson asked what Zeen would like. Kathie, in an animated voice, said, "Here he comes. He's driving up the driveway driving a car. He has got to go home to make a cup of tea."

It was Zeen who spilled the macaroni all over the kitchen floor, Kathie told her mother righteously when she herself was caught in the act.

After tracking Zeen for several months in our study, Edna Adelson one day asked the direct question: "Where is Zeen's house?" Kathie said, "You gotta walk outside," and then, "Wanna go for a walk?" she asked Mrs. Adelson. Mrs. Adelson accepted. And Kathie took Mrs. Adelson for a walk to Zeen's house. Kathie told Mrs. Adelson that she would show her Zeen's sandbox and Zeen's house which had a door that you could open and close. It was a long walk to Zeen's house,

and it was a cold day. Mrs. Adelson complained of the sniffles and her need for a kleenex. Kathie said, "Here's a kleenex" and produced an imaginary tissue which she used to wipe Mrs. Adelson's nose. They walked for a long time and had many interesting encounters on the way. Finally, it dawned on Mrs. Adelson that since Zeen was an imaginary person with an imaginary house, they were probably never going to get there. And they never did.

## First Dream Report

Around the same period, we received the first report of a dream. Kathie wakened one night very much upset and told her mother: "I stuck my foot in it and it turned on." Mother could give us no clues regarding this dream. And while this may not have been Kathie's first dream, it was the first dream reported to mother. In the morning, Kathie reported her dream again but changed the detail to "she bumped her foot."

During this period, our verbatim speech records during visits show an increase in the number of sentences which include a grammatically correct use of "I" but there are still instances in which pronoun reversals appear.

At four years, nine months, Kathie began to ask "Today is what day?" And now, in a very rapid progress, she began to learn the days of the week and the time concepts of "tomorrow" and "yesterday." As I was sorting data for this period, I made a discovery. Our first record of use of the past tense appeared at the same time. Kathie had taken a walk to the outer limits of her home property. She reported when she came back, "I found Robinsons' house!"

## Reconstruction from Memory

One month later we have the first demonstration in our records of Kathie's ability to reconstruct from memory an event of the previous day. Kathie was playing with her mother's cigarette lighter one day. The next day Kathie's mother could not find the lighter and asked where it was.

Kathie thought for a moment and said, "It's on the floor by the rocking chair." (It was.)

As late as Kathie's fifth birthday there were still occasional lapses in her use of "I." On the day of her birthday there was a routine visit to the doctor's office. She told the doctor that today was her birthday. He asked her how old she was. Kathie said, "She's five. No, I'm five years old."

#### Conversation at Five

Here are a few samples of Kathie's conversations at the age of five:

Kathie bumped into a little girl in the doctor's office. Kathie asked, "Who is this?" The little girl said, "Karen." Kathie pursued, "Where does your daddy work?" Karen replied, "At Marshall's." Kathie continued, "Does he work on a farm?" (Kathie's father did.)

Kathie overheard a mother spanking her baby during a visit to Kathie's home. Kathie said, "Don't spank the baby." The mother, embarrassed, said she wasn't hurting the baby. Kathie said, "Oh, did you do it gently and softly?"

Kathie, at five years, one month of age, overheard the bus driver of her school bus say, "Darn!" Kathie asked, "Are you swearing?" "No," said the bus driver, embarrassed. Kathie, persisting, asked, "Do you swear?"

At five years, three months, we have the following observations which tie language and self-concepts together:

We were doing a videotape at Kathie's house to document play and language. Kathie, of course, was aware of the photographer and her visitors from our staff. At one point Kathie was feeding Drowsy, the doll, with the toy nursing bottle. She stopped for a moment and addressed the photographer: "Joy, what are you doing?" Joy said that she was taking pictures. Kathie said, "Oh, are you going to take my picture while I feed the baby?"

At another point, Kathie said that Drowsy was taking a nap. She whispered, "Don't wake him up!" Kathie began to make snoring noises as if pretending that Drowsy was asleep. "That's Drowsy," she explained.

#### Objective Self-Concept

Later, everyone reviewed the tape in the kitchen. As Kathie heard the voices on the tape, she said to Evelyn Atreya, "Evelyn, who is talking?" Mrs. Atreya told her that it was Kathie talking to her mother. As the tape continued, Kathie seemed to listen intently to the voices on the tape and to respond to them. She began to identify her own words on tape and when she heard herself snoring for Drowsy on tape, she laughed out loud.

In these fragments from five years, three months of age, we see versatility in syntax, good pronoun usage, stable forms of "me" and "I" and an objective concept of self which permits her to identify her own voice on tape and to laugh at her own clowning on tape.

In summary, Kathie's capacity for self-representation in play and the acquisition of the concept "I" emerged in a coherent cognitive structure. Yet both were late acquisitions by sighted child expectations which can be placed in the range of two and one-half to three years of age.

#### RENE ZAZZO, PRONOUN USAGE

The relationship between self-representation and personal pronoun usage has not been rigorously examined in the sighted child literature. Zazzo, whose longitudinal study of one child is unique in the literature of developmental aspects of pronoun usage, has produced promising hypotheses which he had hoped would lead to controlled experimental research. His work has not yet been extended.

While our own work was designed without knowledge of Zazzo's study and his hypotheses, there is close correspondence between our findings on self-representation and the pronoun "I," and those of Zazzo.

In his study "Image du Corps et Conscience de Soi," Zazzo follows the grammatical transformations of self-reference pronouns in relation to the child's behavior toward his mirror image. The child was his son, Jean-Fabien, and the mirror observations were recorded between the ages of three months and 2;9 years. (Photographs and home movies were also employed for picture identification, but my summary will confine itself to mirror image.)

## JEAN-FABIEN

At 2;3, Jean-Fabien made his first (and untutored) identification of the baby in the mirror. After a moment's hesitation, he said, "Dadin," the name which he used for himself. (From Jean-Fabien's behavior during this period, it appears that the response "Dadin" is an identification of his image, but the "Dadin" in the mirror is uncertainly himself--perhaps in the nature of another 'Dadin'" (SF).

At 2;4 - 2;5 Jean-Fabien uses a syncretic form of "je" ("ch'sais pas"). At 2;5, Zazzo reports he has the pronouns "elle," "i" ("je" [syncretic]), "ca." At 2;6, he begins to use "moi-tu."

*At 2;8, Jean-Fabien responds to his mirror image for the first time with the phrase, "C'est moi."* (At a later point in the essay, Zazzo adds that the phrase "C'est moi" was accompanied by a gesture in which Jean-Fabien pointed to his own chest. In all later variations in responding to his mirror image, the child used the phrase, "Moi, Jean-Fabien."

At 2;8, the pronoun "je" is disengaged from syncretic forms and the author cites examples of discourse in which "je" is used inventively and in free combination. During the same period, Zazzo reports in his later text, the momentary confusion before the mirror which preceded each self-identification had disappeared.

## EVOLUTION OF SELF-IMAGE

Zazzo's findings corroborate our own in essential aspects: the grammatical transformations of self-

reference pronouns follow a progression that is linked with stages in the evolution of the self-image in which the non-syncretic "I" closes the sequence and signifies the child's capacity to represent himself as an object in a universe of objects. For the sighted child, and more so for the blind child, the achievement of the concept "I" is a cognitive feat. The consistent and versatile employment of the pronoun "I" tells us that the child has attained a level of conceptual development in which he not only endows himself with "I," but recognizes that every "you" for the child is an "I" for the other, and that he is a "you" to the other "I"'s. This is a leap out of his own skin, so to speak, and one that is normally facilitated and organized by vision. Even if there were no mirrors and no pictures to consult, self-image evolves through increasingly complex forms of mental representation in which the body self is given objective form, a "double" as Zazzo suggests, a picture of the self.

For the blind child, the constitution of a self-image and representation through "I" appear in a protracted development. We have used self-representation in play as the only means available to us to examine representation of the self with parallel pronoun usage. If we can grant some equivalence to Kathie's self-representation in play and imagination with Jean-Fabien's response to his mirror representation, we can compare the characteristics of self-representation and pronoun usage in the two children.

## SUMMARY

At 2;2, Kathie and at 2;4, Jean-Fabien both employ a syncretic "I" and, more commonly, their first names for self-reference. Jean-Fabien can now name himself in the mirror. Kathie has no form of self-representation in her play.

At 2;8, Jean-Fabien has "moi" and "tu" in his vocabulary. In the mirror, he identifies himself with the words, "C'est moi." Kathie's "me" and "you" appear in echo responses which inevitably lead to reversals. She cannot represent herself in play.

At 2:10, Jean-Fabien's "je" has completed the course of disengagement from syncretic usage, is used freely and inventively in discourse. The momentary confusion which had preceded mirror identification of himself has now disappeared, which indicates that he now feels at one with his mirror image. It is assimilated to "I." Kathie's "I" is still employed in syncretic forms. "Me" and "you" are still embedded in set phrases as echo responses and appear as reversals. She cannot yet represent herself in play.

At 3:6, Kathie employs "me" for the first time in our records.

At 4:10, Kathie's "I" is now demonstrably a stable form which is used inventively in discourse, but there are still occasional lapses. She can now represent herself in play through dolls; she has invented an imaginary companion.

From this concise summary, we can see that the two children whose "I" first emerged in syncretic form at 2:2-2:4 followed divergent paths in the acquisition of the non-syncretic "I." The sighted child traveled a route which brought him to a stable concept of "I" at 2:10. The blind child's route brought her to the same point at the age of 4:10. Jean-Fabien's travels took him six months. Kathie's took her two years and eight months.

#### BLIND CHILD'S ACQUISITION OF "I"

The parallel developments in self-representation and pronoun usage from these two independent studies speak strongly in favor of Zazzo's view, which is also our own, that the acquisition of personal pronouns goes beyond practice with grammatical tools. It goes beyond the influence of the language environment which we can demonstrate through the incapacities of Kathie in self-reference pronouns, while living in a home with six highly verbal family members. The hypothesis in these two independent studies link self-reference pronouns to self-image.

The blind child's delay in the acquisition of "I" as a concept and a stable form is related to the

extraordinary problems in constructing a self-image in the absence of vision. The blind child must find a path to self-representation without the single sensory organ that is uniquely adapted for synthesis of all perceptions and the data of self. In infancy, the data of self are integrated into a body schema by submitting experience to visual tests. We need only reflect on the hands as a model. Through countless experiments before six months of age, the infant makes the discovery that "the hand" that crosses his visual field, "the hand" that he brings to his mouth, "the hand" that grasps an object is part of himself, an instrument that he controls and the games which he plays with his hands before his eyes are experiments in self-discovery. It is vision that gives unity to the disparate forms and aspects of hands and brings about an elementary sense of "me-ness" for hands.

#### Body Image

Body image is constructed by means of the discovery of parts and a progressive organization of these parts into coherent pictures. In constructing a body image, vision offers a unique advantage that no other sensory mode can duplicate: the picture replicates exactly, and the picture by its nature can unite in one percept or a memory flash all the attributes and parts into a whole. Once the picture is there, it does not need to be reconstituted from its parts.

The blind child has no sensory mode available to him which will replicate his own body or body parts. The blind child is obliged to constitute a body image from the components of non-visual experience available to him, not one of which will give him through objective reference the sum of the parts. His tactile, auditory, vocal, kinesthetic, and locomotor experience will give him a sense of the substantiality and autonomy of his own body, but these sensory modes bind him to egocentric body and self-experience and cannot lead him easily to the concept of self in which the self can be taken as an object which is the indispensable condition for "I." Self-image, which Zazzo suggests is a double, a replicate, a kind of

mirror image of one's own person, is literally a picture of oneself. "I" is the externalization of that picture into a community of pictures each of which is an "I."

For the blind child there is no single sense that can take over the function of vision in replicating body image. When Kathie, at 4:10, identifies her own words and her voice on tape, she has achieved a form of self-recognition which still offers imperfect comparisons with Jean-Fabien's identification of himself in the mirror at 2:8. The voice on tape is an aspect of self, one of the components of self-image that can now be identified in objective form. But the voice does not replicate body image; the picture replicates exactly.

#### Construction of "I"

For the blind child, the level of inference required for the construction of "I" goes beyond that of the sighted child. The blind child must infer from his own consciousness of himself as an entity, a commonality with the consciousness of others who are "I"s; he must construct a world of human objects each of whom is an "I" to himself by granting

forms of substantiality and "I"ness to these human objects that he has identified as attributes of himself. He must do this without the one sensory mode that would describe, through the picture, the commonalities and the generalizations that lead to the concept "I." He will never meet a copy of himself in a mirror or a snapshot album. Yet, when he achieves "I" as a stable form and when he represents himself in play by means of a doll or an imaginary companion, he has indisputably externalized a form of self, reconstituted the self as an object. Our scientific imagination is strained to reconstruct the process.

The blind child's route to "I" and self-representation is a perilous one. Many blind children do not make it. In the blind child population a very large number of children at school age or later do not have "I" in their vocabularies or even self-reference pronouns.

From the study of Kathie and other healthy and adequate blind children, we can understand without difficulty why the pronoun "I" and forms of self-representation are delayed in comparison with sighted children. The more difficult problem is to understand how the blind child achieves this prodigious feat.

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# LANGUAGE AND SELF-REPRESENTATION IN THE BLIND CHILD

## Informal Presentation: Selma Fraiberg

I shall begin by putting this study in context to my own experience. About 12 years ago, when I encountered the first blind children in my clinical practice, one of the children was an autistic blind child, nine years old. This child, like many other autistic children, was nondifferentiated, did not have a concept of "I," had limited language usage, mainly echolalic, and was nonmobile. He represented a type that we meet in many places, and in many institutions for the blind.

After two years of work with this child, I found that my successes were very limited. I was able to help him finally to become independently mobile. He became interested in his surroundings. There was evidence of inventiveness in discourse which we had not seen earlier. The personal pronoun "I" emerged, and then I saw something that I had never seen before. "I" would be present and available to him, and under conditions of stress the pronoun "I" would be lost, and he would revert to self-reference using his own name.

I consider that this case finally was a failure, one that caused me pain for many years. In a way, the interest that I have in blind children grew out of this failure as a way of making amends to Bobby whom I could not help very much.

### DEVELOPMENT OF "I" CONCEPT

In the case of the blind child we are presenting today, we notice that there is a protracted evolution of the personal pronoun "I." The child achieves a syncretic form of "I" at the appropriate age two years one month, actually, but the evolution of "I" that normally takes place within a six- to eight-month period

appears in a protracted form, taking in Kathy's case, two years or more. If we put this in the context of other sensory deprivations, we have an interesting picture. I will mention a few examples which may prove enlightening.

### Neurologically Impaired Child

Judith Rappaport reported on a case of congenital neuropathy which was published in Chess and Thomas. Edna Adelson and I not only heard the presentation at the National Institute of Health two years ago, but saw the films. This child, who had no cutaneous sensation at all, and who had some impediment in articulation, nevertheless had adequacy in language and was capable of representing himself by all means that the examiner could elicit. The personal pronoun "I" was present and had obvious stability in the child's speech.

### The Deaf Child

Second, we have followed a deaf child for two years in the Child Development Project. We waited five years, by the way, to find a child who had been diagnosed as totally deaf in early infancy. This child, Jane, could be tested by means of a standard children's scales, using all scales except the verbal. There were no impediments in development in the locomotor sphere, in adaptive hand behavior, in nonverbal language, and when we used Escalona's Object Permanence Test, this child fell exactly within the norms for intact children.

Jane, confronted with herself in a mirror at an appropriate age, possibly two and one-half, pointed to the mirror image, pointed to herself. Of course, she could not speak. In front

of the family album, with pictures of herself and other children and members of the family, she could point to her own picture and point to herself at two years, nine months of age. She could also point to a picture of mama and papa and point to the appropriate figures. In other words, the capacity for representation was not impaired in the deaf child.

### The Thalidomide Child

In Dr. Decarie's group of thalidomide children, I know of no report of grave impediments in language development, in the capacity to represent in play, and I know of no impediments in the acquisition of "I" as a stable pronoun. These were children who had impediments in prehension and in locomotion because of limb deficiency, although it was a mixed group. Some had upper-extremity impediments and some had lower-extremity impediments.

Again, I remember that during my visit to the thalidomide ward I did not see any children who had not achieved the concept of "I." It would seem, then, that the blind population alone faces a hazard in developing an awareness of self, a concept of self, and the appropriate linguistic forms that accompany the conceptual development having to do with self.

### Subject Kathy

In the case of Kathy, we have a fairly good language biography. And because we were studying forms of play and self-representation as well as many other aspects of development, we have a fairly coherent developmental picture of Kathy from nine months of age to the age of six.

In very brief summary, this is what we found. At the age of two years, one month--while we were most fortunate in having Eric Lenneberg as our linguistic consultant and as designer of our first language study--it was very clear that Kathy's language competence fell well within the range of sighted children. There are many samples in the text to which you can refer. Certainly Kathy did not raise questions in our minds at that

time. There were of course pronoun reversals. "I" appeared in syncretic form as "ahwanna," in which the "I" was muted somewhat. "I" did not appear at any point in the two-year sample inventively in discourse. There was only one puzzle, Eric Lenneberg pointed out that Kathy could neither listen nor respond to a story, which he thought testified to a rather different language beginning. Since Kathy was actually one of the oldest of our children we had no other opportunity to study the language or self-representation development in a blind child at the time. We put the question at the back of our minds waiting for some answers to appear.

At the age of three years, one month, something that should have evolved had not yet occurred in Kathy's case--and remember that she is one of our two highest ranking children in the sample; we must remember also that her language competence at two did not raise any questions. At three years, one month, there were still pronoun reversals, still self-reference by name or "her." In play, she could not represent herself through dolls. During the observations in the nursery there were several sequences in which we found that confronted with play dough with which she was familiar, she could not invent with it. Given a doll, she was unable to represent through the doll. She could not identify parts of the doll. Yet she had a form of play which began to interest us. She could pretend that she was Kathy going to bed, in the sink or the sandbox, which after all is a form of representation. A sink or a sandbox, after all, is not a bed. She could not move to the next stage of representation, however, in which she could represent herself through a doll who goes through the same motions.

We also noticed a confusion in identification of body parts under any circumstance in which the interrogator asked ". . . where is my nose, where is your nose? . . ."

### EMERGENCE OF "I" CONCEPT

At age four and one-half, approximately, the whole picture had altered. Her capacities in doll play

entirely paralleled those of an intact child between the ages of two and three. She had acquired an imaginary companion called Zeen who was capable of all the mischief that Kathy herself would never do. The past tense had emerged very late, but it was there. "I" had become stable but there were still some lapses (examples can be found in the text, and in the transcript of the tape). In syntax, we see considerable complexity, compound and complex sentences, and free and inventive discourse. One sample for instance: Kathy talking to the photographer: "Joy, where are you? What are you doing?" "I am taking your picture." "Oh, are you going to take my picture while I feed my baby?" We cannot even guess what Kathy meant by "taking a picture." There was a discursive quality in this and a complexity in syntax. Also, in a sequence at five years, three months, reported in the record, she was helped to identify herself on tape while listening to one of the recordings. Remembering apparently her own participation and her clowning when she was playing with the doll, Drowsy, she laughed at herself in self-amusement when she encountered herself on tape.

In other words, what we tried to show in the case of Kathy--and we have considerable documentation for our other older children too--is that self-representation in language and in play have correspondence throughout the developmental sequence that we have examined. In the closing portion of our paper we drew some parallels between Kathy's capacities and incapacities in self-representation in language and play and those recorded by Zazzo for his own son, Jean-Fabien. We see that in the case of Jean-Fabien there was some correspondence between the child's capacity to identify himself in the mirror and the emergence of "moi," and finally the disengagement within a very short period of "I" from syncretic usage and its use as a free and inventive form.

## VIDEOTAPE TRANSCRIPTS

In referring to the transcript of the video tape sequences, one can see quite a contrast between the three-year, five-month examples, both in language and in play, and the five-year, three-month examples. To keep the sequences in mind, in our paper the example that we used was three years, one month, and we had that on film. The video tape transcript gives a picture of Kathy at age three years, five months, which means a four-month gap with very slight changes in Kathy's behavior, but a fair picture of what we were trying to do to elicit her behavior, and what she was able to do both in play and speech.

One of the differences in the four-month gap, is that "me" is just beginning to emerge still confused. We were not sure whether we should give her credit for that "me" because there was an echo involved that only we, knowing her language environment, could guess at. In the example that came in the following month, when we finally did give her credit for "me," we see "me" as a form which can be properly attributed.

You may also notice that some of the same procedures were used in the play sequence here which had been used earlier. Maintaining this kind of consistency was one of the things we were trying to do.

## SUMMARY

Our views are that since "I" represents the child's capacity to see himself as an object, the visual impediment presents a problem in conceptualization of self in relation to other objects. That in order for Kathy to understand that she is an "I" to herself and that others are "I" to themselves, she has to infer the attributes of "I" in the absence of vision. It is for these reasons we think that there is a delay in the conceptualization of "I."

# TRANSCRIPT FROM PLAYROOM VIDEOTAPE

Prepared by Evelyn Atreya

"Kathy" (Elizabeth) 3 years, 5 months.

## Section I - Playing in the Sandbox

| Adult                                                                                                                        | Kathy                                                                                                   |
|------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| Want to get up - There we go.                                                                                                | You go lay down.<br>You going to lay down.                                                              |
| You're going to lay down?                                                                                                    | Wait.<br>There ----- sand.<br>Night, night.                                                             |
| Night, night Kathy--night, night.                                                                                            | Now I go to sleep?                                                                                      |
| Night, night Kathy.<br>Now you go to sleep, good night Kathy.                                                                | You sleepy, tired.                                                                                      |
| Are you sleepy, tired?<br>Poor baby, you're very sleepy tired.                                                               | Sand, sand.<br>Sand box.                                                                                |
| Sand Box.                                                                                                                    | Sand box - sand. Sand in the sand -<br>sand, sand. (???)<br>What's that?<br>This sand box - right here. |
| You're right in the sand box.                                                                                                | You're right in the sand box (echo).                                                                    |
| Yes.<br>Do you know what? Someone is going to<br>visit you in the sand box - now you<br>just wait and see who it is. Pierre. | Pierre (echo).                                                                                          |
| Who is this?                                                                                                                 | Dolly.                                                                                                  |
| That's the dolly, yes.<br>Can the dolly play in the sandbox?                                                                 | Can the dolly play in the sandbox?<br>(echo)                                                            |
| Is it all right with you?                                                                                                    | He's going to lay down got to sleep.                                                                    |
| Oh, alright.                                                                                                                 | OK.                                                                                                     |
| Okay, night, night.<br>Goodnight Kathy.                                                                                      | Bye. (???)                                                                                              |
| See you in the morning.<br>Good night. . . . . goodnight.                                                                    | Go to sleep.<br>Box - sand box - sand, sand, sandbox<br>--sand. (???)                                   |
| Now let's put the dolly to sleep.<br>Goodnight Pierre.<br>Goodnight dolly.                                                   | Pierre.                                                                                                 |

Oh he's not dirty, it's clean sand  
really.

Should we put the dolly to sleep?

Goodnight dolly. . . goodnight.

Goodnight dolly.

Where is the dolly?

Goodnight dolly, goodnight Pierre.

See you in the morning.

Shall we cover up the dolly?

Yes, yes, oh yes. . . here's the  
blanket for the dolly, Kathy.

Shall we cover up the dolly?

## Section II - Kathy Playing in a Basin of Water

Where?

Playing in the water.

Sittin in the water.

Swimming in the water.

Swimming.

In the pool.

You'd like to go swimming tomorrow?

Where do you go swimming, Kathy?

Is it cold?

That's a little tiny bathtub.

That's a little bathtub.

When you were a baby you could fit  
into a little tiny bathtub like  
that. Do you remember how big  
were you when you were a baby?  
Can you show me with your hands?  
Remember I told you you were a little  
tiny baby.

Now's the time to give the dolly a  
bath.

Where's the dolly? Where's the  
dolly?

We gotta???

We gotta???

It's dirty.

Put dolly to sleep. (echo)

Ha ha.

Swimming in the water.

??? in water.

White duck (song).

Sittin the water.

Playing in the water.

Sittin in the water.

Swimming in the water.

Swimming.

In the pool.

Swimming, swimming.

Swimming, swimming, I can't go  
there - swimming tomorrow.

Cold. (?)

Swimming.

Whee, Whee,

Ba ba.

Playing in the water.

Playing.

Swimming in the water.

(??)

Feel it.

I feel it.  
Let's let the dolly feel it too.  
Oh yes, we're going to have bathtub  
for the dolly too. Feel the  
dolly's bath. You're going to be  
surprised when you feel the dolly's  
bath.  
Another one - yes --- that's the dol-  
ly's bath.  
And the dolly says, What's Kathy doing  
in my bath.

(??)

Now we'll put the dolly in his bath.  
Oh he's very big-- he doesn't quite  
fit.

What's  
Ow

Now let's shampoo his hair.  
Remember the last time we shampooed  
the dolly's hair?  
Remember Kathy?

(??)  
That's a bath.

Who wants to be left alone.

(??)  
Leave you alone. O.K.  
Leave me alone.

I'm going to shampoo Kathy's hair.

Swimming in the water.  
Sound (water, water).

I'll leave you alone, yes.

Oh you can.  
You gonna leave me alone.

### Section III - Playing a Body Parts Game

Can you find mommy's nose?

There's my nose.

Where's mommy's ear?

Here's mamma's ear.

Where's my shoulder?

There's my shoulder.

Mama shoulder.

Where's my cheek?

Mamma's cheek.  
Song. . . on my cheek  
Put your finger on my cheek. . .

Song. . .

Week (missing word)  
Cheek  
Put your finger on your nose.

There are several very important themes implicit within the verbal description of these data and in the conceptualization that do not necessarily show up in the videotape recording. This is a case in which multimedia do not necessarily expand meaning. I think the best of the meaning is in what has been written in Professor Fraiberg's paper. There are two major themes I want to develop.

One is the theme of self-representation, or the objectification of self. The other is the relationship between intelligence and the objectification of self for the blind child.

This theme of the "self as object" is so important because it is the leading edge of a number of other aspects of self-identification. Of necessity self-identification would be very much different for a blind child than for a sighted child. I have made a list of five aspects of self that I think represent some of these differences.

#### Self as Object

First is the theme Professor Fraiberg has identified so clearly, the *self as object*. I view the essence of the evolution of childhood as being the emergence of the child's sense of his own continuity; that his life does not stop at nighttime, and that it does not start over again in the daytime, and that he is the same intact person despite the flux of feeling and the flux of activities that are continually changing about him. For the reasons Professor Fraiberg described in this paper, I think the objectification of the self has many ramifications for the

blind. It is difficult to imagine any domain of experience in which the sighted child does not have enormous advantages over the blind child in perceiving the continuity of his own physical self in visual space.

#### Self as Doer

Another aspect of the self which presents facets that are probably very different for the blind child is the *self as doer*. We know that we live in an achievement-oriented society. We have to think of the blind child as a member of such a society, and consider how achievement motivation and gratification could operate successfully for a blind child in the absence of visual incentives and visual rewards. The blind child is subject to paying a higher psychic toll for the evolution of his identity than is the normally endowed child, who can readily slip into patterns of achievement acculturation without any primary barriers. The blind child confronts a primary barrier when he cannot use the modality of vision to objectify the achievement motives and the achievement rewards that saturate the visual environment of which he is only a partially participating inhabitant.

#### Self as Detached Observer

Next is the *self as detached observer*. When I was thinking about this point I was reminded of my daughter's experience in a Montessori nursery. My child, who is quite intelligent and very active at home, did not, for the first eight months of the year, commit her own activity to anything that went on at the nursery school. She was a detached observer. She learned a great deal by observing. She was able to pace her own commitment to the activities of the program. If she had not had two

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psychologists for parents, who were willing to let this pacing run its course in its own style, I am sure that these conscientious Montessori nursery school people would have recommended that the child be referred to a psychologist on the supposition that her passivity represented pathology. There was nothing wrong with her at all. She simply wanted to pace her own activities and gauge her own commitments of self.

I think a blind child confronts enormous difficulties in this respect because he has to objectify virtually all his participation in terms of overt action. He has to manipulate. He has to engage in close social contact--which many three and four and five year old children simply do not want to do. And we deprive a child of an aspect of himself when we force him into activities for which he may not feel ready. The blind child cannot resist the impetus of people constantly pulling him into fresh activities which, of course, are his primary mechanisms of learning.

#### Self as Image to Others

Then there is the *self as image to others*. We know when we teach child psychology and when we think about it that there are tremendous anxieties and gratifications of self-concept based on physical appearance, and on what other people might be presumed to think of one's own appearance. Of course this is an area of ego evolution in which the blind child has all the cards stacked against him. He has all the inputs for anxiety about his appearance and none of the visual inputs for anxiety reduction. It is a commonplace equation for disability to be associated with disfigurement, and the blind child can have no way of reassuring himself that he is not disfigured.

#### Self as Competitor

Then there is the *self as competitor*. We know that we live in a highly competitive society, and we know that children start to become acculturated to these values of competition early in life. It is not at all uncommon to find children at ages two and one-half, three and one-half, starting to show the features of

competition which are the hallmark of our American lifestyle. The blind child is perpetually handicapped in that he must start behind the others in this aspect of ego evolution.

#### Attainment of Self-Objectification

Those of us who work with people who are handicapped have two tendencies: one is to exaggerate the seriousness of the handicap, and the other is to minimize the seriousness of the handicap. If we are going to strike some kind of balance, we should not exaggerate nor minimize. When we are talking about blind children, we should come to some objective sense of where the child really stands in the course of ego development. Others must have written about this topic; however, the authors of this paper deserve much credit for developing the idea of ego development in the young child with the notion of the objectification of the self.

The videotape confirms that the child was very bright; was inventive in play; had supportive, intuitive parents; was well-behaved, mischievous, and fun-loving; independent in dressing, feeding, and play; and had a normal range of vocabulary, phrase, and sentence patterns--all of which are extremely important. Yet this child is two or two and one-half years behind in objectification of self.

I would like to examine that objectification of self as a process with respect to intellect and cognitive competence. The acquisition of the objectified sense of self in all its various forms is a supreme act of intellect, possibly the supreme act of intellect throughout the life span. We fail to recognize the tremendous complexity of this process because in the normal child it occurs over an extended period of time in an enormous number of cumulative experiences, no single one of which is necessarily determinative in itself.

The true complexity and difficulty of the self-learning process becomes more apparent when we subtract the element of self-visualization. I refer the reader back to the concluding pages of Professor Fraiberg's paper for illustration of this point. In the task of

reconstituting the self as an object, we can agree with the author that: "Our scientific imagination is strained to reconstruct the process."

### An Act of Intellect

Why is the intellectual task of self-objectification so much more difficult for the blind than for the sighted? This can be understood more clearly if we give a definition of vision that stresses the cognitive or information-processing aspects of the visual modality.

One definition that I would emphasize in this context is: *vision is that form of information input which allows the easy summation of simultaneous spatial reality independent of time.* Perception in the visual world, especially perception of the self in the visual world, can be organized at a leisurely pace, relatively speaking, under the child's own control. He can spend limitless time studying his own reality in the mirror to the exclusion of all other inputs. He can see himself in an instant, fully embedded in a spatial reality that incorporates the physical objects of his familiar world and the interpersonal reality of familiar people and total strangers. He does not have to execute any cognitive struggle of memory and information retrieval in order to establish a reasonably coherent domain in which his own existence is demonstrably as genuine as the other aspects of physical reality. The blind child is obliged to remember what the sighted child can effortlessly reconstruct in the blink of an eye.

The only way that the blind child can construct a coherent sense of reality is by the continual mental process of retrieving the limited experience of the past and combining it with the continuously changing present. From the psychological point of view, the outstanding characteristic of vision is its simultaneity. No other sensory-perceptual mode has this characteristic. In its absence, all the other modalities put a tremendous burden on the mind's ability to synthesize a coherent objective sense of self and other in a sensory world that never stands still.

I submit the proposition that it takes a high level of inferential intelligence to carry this burden successfully. The blind child must have exceptional resources for all kinds of successful information-processing operations--such as categorization, abstraction, and generalization--in order to formulate a coherent sense of self based upon raw materials of incomplete perception that are continuously fading into the past. If he does not have or cannot mobilize (and that is a loaded phrase--there is a lot of meaning in that notion of "cannot mobilize"), the resources of adaptive intelligence that are required to fulfill this integrative task, then the organization of his objectified self remains incomplete.

As Professor Fraiberg says later in her paper, "The blind child's route to 'I' and self-representation is a perilous one. Many children do not make it. So, to the extent that personality organization is a product of adaptive intelligence, the blind child is vulnerable to the disabilities of an uncompleted sense of self unless his intellectual grasp is sufficient to fulfill the essential task of constructive synthesis."

### Facilitating the Process

Judicious use of various intervention techniques might be useful in helping blind children attain the goal of self-objectification. For example, the tape recorder is an instrument with which children can easily re-establish some of the events of their own listening experience. A blind child with a tape recorder under his own control can gain almost unlimited access to his own voice and the voices of familiar others, and this access could play a substantial role in concretizing the reality of his personal self and the continuity of his interpersonal relationships. (Studies in my laboratory have shown that sighted babies as young as six months place a very high value on redundant listening experience when various devices are used to place the tape recorder under the infants' own control.)

With such an assist at being able to reconstruct his own past experience, the blind child might find it easier to develop a sense of yesterday and last week, thus gaining further reassurance of the continuity

of his own existence over time. It should be possible to design other measures as well, for fulfilling similar functions in establishing guideposts that can help the blind child traverse the perilous route to "I."

## General Discussion

### DEVELOPMENT OF "I" SENSE

Dr. Chess opened the discussion by suggesting an exercise in imagination. While listening to Dr. Friedlander's comments on the sense of "I" that a young child gets from looking at himself in the mirror, it had occurred to her that there are some cultures in which mirrors do not exist. Ours is a mirror-infested culture, but someone living in a primitive society which does not produce burnished metal would never see himself if there was no still body of water in his environment. Under such circumstances one may see a representation of oneself in all the other people, but not one's own person. While she knew of no studies of this, it seemed reasonable to assume that people in such circumstances develop a sense of self that is quite accurate. It might be useful to stretch one's imagination and consider living in a world in which the visual sense did not exist. In such a world there would be a completely different set of norms for things like language development, and all sorts of devices for coping would have been worked out. It certainly could be done. After all, the mole has no eyes, yet he propagates. We sometimes forget that the main reason for so much activity in trying to bring children who have lost a sense, whether auditory or visual, to the norms of the world of intact people is not for the sake of some binding ideal standard. It is simply because they have to live in that world, and it is for this practical reason only that it is necessary to do this. It would be quite possible to have blind children live in a world that would not demand all of

these things, but they would have to stay in a special environment. They would not be able to participate and move in the world beyond it. Looking at it this way, she had found herself turning the whole thing around in terms of sense of self. We are demanding a time table for the development of a sense of self that has relevance because we want to have these children perform with sighted children. It is right to do this; we should aim at as complete inclusion as possible, but we should also remember that that is the reason.

Dr. Friedlander replied that we have to provide the ability to choose. The child must have the capability to function in the sighted world. He should not be told he is better off in a segregated one. He should have the option not to participate if he so chooses, but only after we have made sure this is not because he is incapable of participating.

### ACHIEVEMENT TIMETABLE

Dr. Chess agreed with this. It was true that, if the decision were to be left to the children, there would be no freedom left to decide by the time they were old enough to do so. Certain decisions had to be made early in order to give that freedom later. However, she felt the earlier discussion had sounded as if there were some standards that were absolute. If a child achieves a given stage of development early enough to be included in the normal world of activity, then there is no reason for making a project out of achieving it earlier. If without intervention he achieves it so late that the normal

track is closed to him, then it becomes reasonable to have a major project to see if one can hasten the process. And the same holds for those who without such a push would not achieve it at all.

## ROLE OF VISION

Dr. Fowler suggested that, although he did not want to minimize the role of vision in development, the mirror was not crucial to the concept of self. The construction of self can proceed on a much more shallow gradient of learning by virtue of the fact that to see another person is to see a constructed whole with all of the parts related visually. There are some problems of representation in development of the object concept at an early stage, but the fact is that a person can see this coherent whole once he has constructed the object in terms of a permanent identity in babyhood. He is then able to see many parts of himself, and see how they are connected with one another visually with the obvious exceptions of face, head, and back parts which are more difficult. Because one has many parts to fill into this puzzle through the aid of vision, the conceptual leap to make the final integration of constructing the self is perhaps not so great for the blind. He felt that perhaps the many steps that are involved in the development of the object concept had been underestimated; the many connections that the baby has to make. Where Dr. Friedlander spoke of the simultaneity of the visual world, there was a whole language code, an organization of concepts that has to come about. Initially the baby identifies the world in terms of place and movement concepts. He does not put these together until, after a variety of experiences of seeing objects constantly displaced, he finally makes the construction and inference of the fact that an object has a permanent existence. Dr. Fowler felt that in the effort to point out the tremendous importance of the simultaneity of the visual act, a whole sequence that a normal child has had to go through, even *with* the aid of the visual modality, had been omitted.

## ROLE OF OTHER SENSES

Dr. Prescott recalled that one of the comments Dr. Friedlander made was that the blind child cannot appreciate, or has no meaning for, the words "you look so pretty," or "your dress is pretty," etc. Dr. Prescott raised the question, to what extent the other sensory systems could be used in the same systematic way, like "you feel so good," or "you smell so good," "you sound so good." We do not use these other sensory systems systematically, as we do vision. The comment "you look so good" is a commonplace and it is automatic, but we have no equivalents for the other senses. So the question is, to what extent it would be possible to compensate if we really used these other sensory systems systematically.

Dr. Friedlander commented that smell was used in education in the Montessori school, but simply as a matter of discrimination learning. It was not utilized in the way suggested by Dr. Prescott.

## BODY STIMULATION

Mrs. Fraiberg referred to the previous day's discussion of somatosensory deprivation. It was, she said, very obvious that everything we do to create pleasurable sensation in the body ego itself, which must precede the sense of self, is going to enhance body image on a primitive level and will perhaps begin the progress toward a concept of self and toward "I." She could not say that their own data would indicate exactly that those children who received adequate bodily stimulation were those who regularly achieved "I." There was actually one case in which the data were confusing in this respect. But there was enough evidence to show that this is one place where we can effectively intervene, that the building of self-image begins with the building of body image and therefore all that we do in early intervention in assisting parents to make body contact with their child and to enhance the body self will presumably ultimately show up in an enhancement of self.

## TACTILE VISION SUBSTITUTION SYSTEM

Returning to the question of the role of vision, Dr. Prescott suggested that its overriding importance for the objectification of self can, in fact, be tested with Dr. Bach-y-Rita's Tactile Vision Substitution System. The use of the TVSS could provide through a tactual stimulation a, so to speak, quasi-visual perceptual image during the very early critical periods of development of a blind child. The developmental lags that Mrs. Fraiberg described should then be absent, if that type of imagery is as crucial as has been suggested. It was, he felt, a very happy convergence of this issue with what Dr. Bach-y-Rita discussed in his presentation.

Dr. Friedlander commented that it would be quite a developmental task for a rather young child to be able to interpret skin inputs representing external spatial domains. It seemed to him a major problem of cognitive synthesis which possibly could be dealt with through a training program where the child would feel objects and then feel the skin input on the stomach or somewhere else. If one knew anything about the problems of two-dimensionality and three-dimensionality in the development of sighted children, one would see these problems raised exponentially when a child felt an object in the round and then got a two-dimensional representation on the belly. There would be many problems. For instance, normal children's idea of space is chaotic when it is not right under their immediate control.

Dr. Fowler saw Dr. Bach-y-Rita's instrument as something to experiment with in later more refined forms even with babies. The child can use it to make some inference since it empirically brings some input. It is a source of data for inferences and the blind child does not now have these inferences. The eye is a very precise instrument; this would be a cruder form, but later versions could be more refined. We should be able to construct experiences for the child where he can coordinate this quasi-visual perceptual input, however crude, with the factors of real experiences. It may prove to be a considerable aid in the long run.

Dr. Bach-y-Rita gave the perception of his own hand movement by the child as an example. One thing one saw even with older subjects was the fascination with their own hand movements and the initial learning of "hand-eye coordination." When a subject was sent into a room, for instance, to search for and pick up a telephone, initially he would overreach or underreach, and he did not coordinate the reaching with the perception of the location. But he would then bring his hand into the view of the camera, into the camera's field, and go down for the telephone accurately. As he progressed he would come to reach more and more laterally. Dr. Bach-y-Rita thought that, even at a very young age, this kind of task of coordinating or perceiving one's own movement, foot movements, hand movements and so forth, would be extremely important.

COMMUNICATION DEVELOPMENT IN THE FIRST THREE YEARS OF LIFE\*

Formal Presentation: Daniel Ling and Agnes H. Ling\*\*

COMMUNICATION MODE STUDY

The purpose of this study was to investigate the extent to which different modes of communication were used during the first three years of life and to determine how these were affected by the children's age, sex, and position in the family. Our goal was to time-sample both verbal and nonverbal communicative behaviors among normally hearing infants and their mothers so that we could later compare the frequency with which such behaviors occurred in hearing-impaired infants and their mothers before and after participation in an aural rehabilitation program.

Spitz (1965) has stated that there is a paucity of data relating to the inception and growth of communication between mothers and their babies. He suggests that, whereas communication between adults has a common base or code of verbal and gestural symbols, there is a conspicuous inequality in the means available to a mother and to her baby, since the infant, at first, has

only a very restricted repertoire of imprecise nonverbal signals at his disposal. For example, when a baby cries a mother has to rely on information such as time of last feeding, checking diaper, etc. to interpret the meaning of the cry.

Both Lewis (1951) and Piaget (1953), who made detailed studies of their own children's prelinguistic development, observed vocal expression from the first days of life. Early responses to the speech of others consisted of the cessation of crying, and later, the onset of smiling or some other facial or bodily movement. Lewis (1963) reported that it was not until about three months that his baby vocalized when spoken to, and that the baby's first "understanding" of words and phrases (at about 10 to 12 months) was not based on the actual phonetic form but rather on pitch, stress and intonation cues. In contrast, present day psycholinguists have been concerned almost exclusively with the acquisition of morphology and syntax. As Friedlander (1970) pointed out, they have not yet attempted to relate the emergence of such verbal skills to the child's previous experience and behavior.

The elements of early behavior must be identified before measurement can be undertaken (Hutt and Hutt, 1970) and previous studies of mother-infant interaction have therefore been descriptive rather than quantitative (David and Appell, 1959; Ainsworth, 1963; Wolff, 1963; Robertson, 1965). Even in adults, the nonverbal aspects of communication have not yielded readily to precise description (Duncan, 1969). Birdwhistell

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(1952) laid the foundations for the systematic study of kinesics or "body English" which deals with the manner in which human beings communicate through body movement, gesture, posture, facial expression and eye movements. The work of Trager (1963) gave impetus to the detailed study of paralinguistic aspects of communication by adults such as vocalization, voice quality, intensity, pitch, speech non-fluencies and non-language sounds such as laughing, yawning and grunting. Hall (1963) developed the area of proxemics, which is concerned with the use of social and personal space. The studies mentioned above served to provide a repertoire of verbal and nonverbal behavior which could be labeled communicative and from which we selected items for the checklists employed in this study.

To investigate the extent to which different modes of communication were utilized by mothers and by their children, a measure of frequency was required. The time-sampling method was chosen following Rheingold (1961) who found it to be sensitive in measuring the amounts and kinds of stimulation provided by mothers in their homes and by caretakers in an institution. In time-sampling, the occurrence of preselected behaviors is checked at very short, specified intervals (usually every 10, 15, 20 or 30 seconds). This and other methods of observation are discussed in detail by Bijou, Peterson, Harris, Allen and Johnston (1969), by Hutt and Hutt (1970) and by Lytton (1971).

## METHOD

### Subjects

We observed 48 children in communication with their mothers. A first-born boy, a first-born girl, a last-born boy and a last-born girl were studied at each of the following age levels: 1, 3, 5, 7, 9, 11, 14, 18, 24, 28, 32 and 36 months. All families were of middle class background and were located through their pediatricians, who referred them as willing to cooperate.

### Procedure

Two checklists were devised: one to record the types of communication used by the mother, and the other to record those used by the child. Items were classified as pertaining to one of eight communication modes: vocal behavior, verbal behavior, eye contact, facial expression, body posture, action, demonstration and gesture. The particular behaviors observed are listed as an appendix. Items were selected only after extensive pilot work had shown them to be the most appropriate for our purpose. The two checklists are not identical. For example, the mother-to-child list does not include certain vocal items such as crying, whimpering, screaming and jargon which were found to be appropriate items for infants but were never observed among mothers in our pilot work. Similarly we found that certain verbal items such as syntactically correct phrases, simple and complex sentences could be readily identified and checklisted during the brief observations of mothers whereas the immature utterances even of older children, often precluded such fine distinction. Children's utterances of more than one word were therefore classified as either a "word combination" or "connected speech." Items occurring simultaneously were checked. Thus, if a mother was smiling to her baby while rocking him, then the items checked would be "smiling" and "positive body posture." When an item of verbal behavior was recorded, a checkmark also indicated whether it was an "imitation," "reduction" or "expansion," whether it contained "expressive cues" or was "related to the situation."

Observations were made in the baby's home during the late morning or early afternoon. A one hour period of observation was found to be optimal. Most infants in their early months are rarely able to remain awake and alert for longer. Visits were therefore arranged to coincide with the infant's normal waking spell. Two observers, who were qualified speech and hearing therapists, were trained in the use of each checklist until an inter-observer reliability of better

than 90 percent was achieved for each 100 observations. One observer was then assigned to observe the mother and the other, the child. Observers made a 1-second observation every 30th second for the first ten minutes of each consecutive quarter hour until 100 observations had been completed. The faintly audible clicks of a stopwatch used by one of the observers signaled each observation interval.

To determine whether the checklists administered by these observers yielded a representative and reliable sample of ongoing communicative behavior, the checklists were administered on four consecutive days to three mother-child pairs. Data were found to provide highly consistent results and to reflect the amount and type of communication measured by means of event-sampling.

Prior to visits mothers were told that we were conducting a study of infant development and were asked to carry on customary activities such as changing, feeding, bathing and playing with the baby. The observers explained that during the session they would avoid interacting with either mother or baby by lowering their gaze. Formal observations were not begun until the mother and child were apparently accustomed to the presence of the observers. Siblings, if any, were not present during the observation period.

Inter-observer reliability was monitored during the course of the study by comparing the two checklists for entries under "eye-contact." This behavior required the simultaneous participation of both partners. Agreement between observers was usually better than 98 percent.

### Statistical Analysis

In order to determine whether the frequency of mother-to-child and child-to-mother communication was significantly related to age, sex or position in the family, a series of 18 separate  $12 \times 2 \times 2$  factorial analyses of variance were carried out. For the first two analyses, data for all eight modes were pooled to examine the overall frequency of mother-to-child and child-to-mother communication. Data on the frequency of mother-to-

child and child-to-mother communication observed in each of the eight modes were then separately analyzed.

## RESULTS

We made 100 observations, each of 1 second duration, on 48 mothers and their children in the course of a one hour period with each pair. In the 4,800 observation intervals, mothers communicated on 2,912 occasions, and children on 2,018. Thus on most observation intervals communication was noted for the mother, the child or for both. The number of events recorded in mother-to-child and in child-to-mother communication during each set of one hundred observations is shown in Table 10. The number of events observed in all eight modes is presented in relation to each child's age, sex and position in the family. Mothers communicated significantly more often with first-born than with last-born children ( $F = 25.28$ ;  $df = 1, 11$ ;  $p < 0.01$ ) and with younger more frequently than with older children ( $F = 15.53$ ;  $df = 11, 11$ ;  $p < 0.01$ ). Thus mothers with first-born babies in the first year of life were the most attentive ( $F = 3.87$ ;  $df = 11, 11$ ;  $p < 0.05$ ). Sex of the baby did not influence the frequency of mothers' communication with their children. No significant differences were found in the frequency of child-to-mother communication, with respect to age, sex or position in family.

### Communication Modes

The mean frequency with which each mode of communication was used by mothers to their children at each age level is shown in Table 11, and by the children to their mothers, in Table 12. These tables also show the mean number of observation periods during which no communication was noted. Communication by mothers of one-month old infants was noted on more than 90 percent of the occasions during which they were observed. At this stage, the main modes of communication were body posture and action, but verbal and vocal modes, eye contact and facial expression were also used on numerous occasions. The frequency with which mothers communicated declined in relation to age, but even with children in their

TABLE 11

The Number of Mother-to-Child and Child-to-Mother Communication Events Observed in Relation to Each Child's Age, Sex, and Position in Family. Each Cell Shows the Number of Events which Occurred During the Course of the 100 Observations Made on One Individual. Since Two or More Modes of Communication Were Often Employed Simultaneously Some Cells Contain Entries Greater than 100.

| Child's age<br>in months | Mother-to-Child |      |           |      | Child-to-Mother |      |           |      |
|--------------------------|-----------------|------|-----------|------|-----------------|------|-----------|------|
|                          | First Born      |      | Last Born |      | First Born      |      | Last Born |      |
|                          | Boy             | Girl | Boy       | Girl | Boy             | Girl | Boy       | Girl |
| 1                        | 225             | 229  | 188       | 155  | 36              | 46   | 50        | 19   |
| 3                        | 160             | 183  | 175       | 161  | 90              | 61   | 71        | 57   |
| 5                        | 206             | 160  | 127       | 126  | 39              | 37   | 25        | 53   |
| 7                        | 213             | 196  | 91        | 78   | 83              | 41   | 54        | 38   |
| 9                        | 188             | 183  | 82        | 97   | 48              | 61   | 45        | 41   |
| 11                       | 144             | 103  | 68        | 117  | 70              | 44   | 68        | 37   |
| 14                       | 80              | 81   | 79        | 89   | 103             | 72   | 37        | 71   |
| 18                       | 56              | 110  | 77        | 76   | 53              | 72   | 45        | 35   |
| 24                       | 108             | 64   | 82        | 83   | 50              | 75   | 63        | 36   |
| 28                       | 65              | 126  | 76        | 94   | 71              | 55   | 62        | 81   |
| 32                       | 79              | 119  | 66        | 93   | 71              | 90   | 59        | 69   |
| 36                       | 51              | 58   | 62        | 90   | 54              | 74   | 70        | 77   |

second and third years, communication was noted on about half of the observation intervals, the verbal mode predominating. At all age levels, mothers employed several modes simultaneously. Infants communicated less frequently than their mothers, particularly in the first year, and, regardless of age, tended to use only one mode during a communication event.

#### Frequency of Vocal Behavior

Mothers made little use of the vocal mode although they employed vocalization more frequently with younger than with older babies ( $F = 5.57$ ;  $df = 11, 11$ ;  $p < 0.01$ ). No differences in mothers' vocal behavior were observed with respect to the baby's

sex or position in the family. First-born babies used more vocal behavior than last-born ( $F = 6.24$ ;  $df = 1, 11$ ;  $p < 0.05$ ) and babies in the first two years were more vocal than those in the third ( $F = 3.35$ ;  $df = 11, 11$ ;  $p < 0.05$ ).

#### Frequency of Verbal Behavior

Mothers of first-born babies communicated verbally to a greater extent than did mothers of last-born ( $F = 20.60$ ;  $df = 1, 11$ ;  $p < 0.01$ ). Neither the age nor sex of the child affected the frequency of the mothers' verbal behavior. Mothers of young babies talked as often to them as did mothers to their children aged two or three years. As might be expected,

TABLE 12

Mean Number of Times Mothers of Children at Each Age Level Used Each Mode of Communication in the Course of 100 Observations. Each Cell Entry Represents the Mean of Summed Observations for the Mothers of First-Born and Last-Born Children of Each Sex. Since Two or More Modes of Communication were Often Employed Simultaneously, All Row Means Add to More than 100.

| Child's age<br>in months | Vocal | Verbal | Eye<br>Contact | Facial<br>Expres-<br>sion | Body<br>Posture | Action | Demon-<br>stra-<br>tion | Gesture | No Mode<br>Attempted | Sum of<br>Means |
|--------------------------|-------|--------|----------------|---------------------------|-----------------|--------|-------------------------|---------|----------------------|-----------------|
| 1                        | 9.75  | 27.00  | 18.50          | 16.00                     | 80.75           | 46.50  | 0.00                    | 0.75    | 7.00                 | 206.25          |
| 3                        | 11.75 | 33.00  | 19.00          | 30.75                     | 30.75           | 43.50  | 0.25                    | 0.75    | 23.25                | 193.00          |
| 5                        | 5.00  | 36.50  | 11.00          | 22.50                     | 35.75           | 42.00  | 0.25                    | 1.75    | 28.00                | 182.75          |
| 7                        | 5.25  | 34.25  | 19.25          | 18.00                     | 24.00           | 42.75  | 0.25                    | 0.75    | 33.50                | 178.00          |
| 9                        | 7.50  | 25.75  | 11.75          | 26.00                     | 24.50           | 40.50  | 0.00                    | 1.50    | 35.00                | 172.50          |
| 11                       | 3.50  | 31.50  | 10.25          | 15.75                     | 12.00           | 32.75  | 0.50                    | 1.75    | 37.50                | 145.50          |
| 14                       | 4.75  | 28.00  | 10.75          | 12.75                     | 6.75            | 16.25  | 1.75                    | 1.25    | 49.00                | 131.25          |
| 18                       | 2.50  | 27.25  | 9.75           | 10.50                     | 14.00           | 12.25  | 2.25                    | 1.25    | 55.50                | 135.25          |
| 24                       | 1.75  | 35.75  | 8.50           | 10.25                     | 8.25            | 14.00  | 3.00                    | 2.75    | 48.25                | 132.50          |
| 28                       | 2.75  | 36.75  | 6.25           | 15.75                     | 11.00           | 16.25  | 0.75                    | 0.75    | 50.50                | 140.75          |
| 32                       | 2.50  | 40.25  | 8.00           | 13.75                     | 6.50            | 10.75  | 4.50                    | 3.00    | 48.75                | 138.00          |
| 36                       | 0.50  | 33.75  | 7.50           | 6.00                      | 5.00            | 10.25  | 1.25                    | 1.00    | 55.75                | 121.00          |

TABLE 13

Mean Number of Times Children at Each Age Level Used Each Mode of Communication in the Course of 100 Observations. Each Cell Entry Represents the Mean of Summed Observations for the First-Born and Last-Born Children of Each Sex. Since Two or More Modes of Communication Could Be Employed Simultaneously, All Row Means Add to More than 100.

| Child's age<br>in months | Vocal | Verbal | Eye<br>Contact | Facial<br>Expres-<br>sion | Body<br>Posture | Action | Demon-<br>stra-<br>tion | Gesture | No Mode<br>Attempted | Sum of<br>Means |
|--------------------------|-------|--------|----------------|---------------------------|-----------------|--------|-------------------------|---------|----------------------|-----------------|
| 1                        | 11.50 | 0.00   | 19.00          | 9.00                      | 0.75            | 0.00   | 0.00                    | 0.00    | 69.25                | 109.50          |
| 3                        | 14.75 | 0.00   | 20.25          | 19.75                     | 4.50            | 10.50  | 0.00                    | 0.00    | 49.25                | 119.00          |
| 5                        | 10.75 | 0.00   | 12.50          | 10.00                     | 0.75            | 4.50   | 0.00                    | 0.00    | 68.75                | 107.25          |
| 7                        | 15.25 | 0.00   | 18.50          | 13.00                     | 1.00            | 6.25   | 0.00                    | 0.00    | 59.00                | 113.00          |
| 9                        | 15.50 | 0.00   | 11.50          | 13.50                     | 4.50            | 3.25   | 0.00                    | 0.50    | 60.75                | 109.50          |
| 11                       | 18.75 | 0.00   | 9.75           | 10.00                     | 4.00            | 11.25  | 0.75                    | 0.25    | 55.25                | 110.00          |
| 14                       | 26.75 | 0.50   | 10.75          | 11.75                     | 3.50            | 16.00  | 0.00                    | 1.50    | 52.25                | 123.00          |
| 18                       | 16.75 | 2.75   | 10.00          | 9.00                      | 2.25            | 5.75   | 3.25                    | 1.50    | 63.25                | 114.50          |
| 24                       | 18.50 | 6.25   | 9.00           | 9.75                      | 1.00            | 7.00   | 3.75                    | 0.75    | 57.50                | 113.50          |
| 28                       | 3.75  | 29.75  | 6.75           | 9.50                      | 4.25            | 11.25  | 1.50                    | 0.50    | 54.75                | 122.00          |
| 32                       | 4.25  | 30.75  | 8.00           | 11.75                     | 1.75            | 12.25  | 1.75                    | 1.75    | 50.50                | 122.75          |
| 36                       | 4.50  | 33.25  | 6.75           | 5.00                      | 3.75            | 11.75  | 2.50                    | 1.25    | 54.00                | 122.75          |

older children talked more than younger children ( $F = 28.10$ ;  $df = 11, 11$ ;  $p < 0.01$ ). No verbal behavior was observed among babies of 11 months or younger, word approximations having been categorized as vocal rather than verbal items. The earliest age at which utterances were sufficiently clear to be classified as words was 14 months, no babies aged 12 or 13 months having been included in the present study. All of the children over two years of age were observed to communicate verbally. Differences in the extent to which children used the verbal mode were not related to sex or position in the family.

#### Eye Contact

The frequency with which eye contact was observed was almost identical for mothers and for their infants. This was to be expected since eye contact involved the two in simultaneous interaction. The frequency of eye contact was not found to be related to the child's age, sex or position in the family.

#### Facial Expression

The most frequent use of facial expression was noted among mothers and their three-month old infants. Facial expression was noted most often in mothers of first-born children ( $F = 3.73$ ;  $df = 11, 11$ ;  $p < 0.05$ ). The frequency with which facial expression was observed in children did not vary significantly with age, sex or position in the family.

#### Body Posture

Mothers of one-month old infants communicated predominantly through body posture. This type of communication was used more frequently by mothers of younger babies than by those of older babies ( $F = 34.69$ ;  $df = 11, 11$ ;  $p < 0.01$ ), and more frequently with boys than with girls ( $F = 5.67$ ;  $df = 1, 11$ ;  $p < 0.05$ ). The highest proportion of mothers' communication by body posture occurred with first-born children between five and eleven months ( $F = 4.42$ ;  $df = 11, 11$ ;  $p < 0.05$ ). The reliability of this result was reflected in the similarly frequent use of body posture noted among their children.

#### Action

Action proved to be a major means of communication during the first year. Mothers used this mode more frequently with younger children ( $F = 15.93$ ;  $df = 11, 11$ ;  $p < 0.01$ ), and with their first-born ( $F = 5.88$ ;  $df = 1, 11$ ;  $p < 0.05$ ), thus especially with first-born babies in the early months of life ( $F = 2.85$ ;  $df = 11, 11$ ;  $p < 0.05$ ). Neither age, sex nor position in the family affected the frequency with which children used action as a means of communication.

#### Demonstration

No significant differences were noted with regard to the frequency with which demonstration was used by mothers. Older children used demonstration more frequently than younger ones ( $F = 3.94$ ;  $df = 11, 11$ ;  $p < 0.05$ ), but in all, this mode was seldom observed.

#### Gesture

Some mothers used gesture even to their very young babies, but this mode of communication was rarely observed. Gesture was occasionally noted among the children, but not before the age of nine months.

#### Types of Vocal and Verbal Behavior Employed

The frequency of occurrence of specific vocal and verbal items observed in mother-to-child, and in child-to-mother communication is presented in Table 13. Data in this table are grouped in relation to four age levels: the first six months, the second six months, the second year, and the third year of life. Figures in each cell show the mean number of times each type of vocal or verbal behavior occurred during 100 observation intervals. Mothers made little use of the vocal mode. With children in the first six months, mothers used vocalization (cooing with various vowels) during less than six percent of the observation intervals and whispers (with and without words) were noted about half as frequently. Communication by laughing, syllabic babble and word approximation was rare. Fewer vocalizations and whispers were

TABLE 14

The Extent to Which Different Types of Vocal and Verbal Items were Used by Mothers and by Their Children in Each of Four Age Groups (N = 12/group). Each Cell Entry Gives the Mean Frequency with Which a Particular Type of Behavior was Noted in the Course of 100 Observations.

|                    | Child's age in months |             |              |              |
|--------------------|-----------------------|-------------|--------------|--------------|
|                    | <u>1-3</u>            | <u>7-11</u> | <u>14-24</u> | <u>28-36</u> |
| MOTHER-TO-CHILD    |                       |             |              |              |
| Vocal Behavior:    |                       |             |              |              |
| Whisper            | 2.50                  | 1.50        | 0.33         | 1.00         |
| Laugh              | 0.50                  | 0.75        | 0.33         | 0.58         |
| Vocalization       | 5.67                  | 2.67        | 2.00         | 0.25         |
| Syllabic Babble    | 0.17                  | 0.50        | 0.33         | 0.08         |
| Word Approximation | 0.00                  | 0.17        | 0.00         | 0.00         |
| Verbal Behavior:   |                       |             |              |              |
| Single Word        | 7.67                  | 6.17        | 6.50         | 5.00         |
| Phrase             | 5.33                  | 5.75        | 4.25         | 4.42         |
| Simple Sentence    | 9.92                  | 8.42        | 10.33        | 10.25        |
| Complex Sentence   | 0.92                  | 1.00        | 2.08         | 4.50         |
| Question           | 8.83                  | 9.00        | 7.00         | 10.08        |
| CHILD-TO-MOTHER    |                       |             |              |              |
| Vocal Behavior:    |                       |             |              |              |
| Whimper            | 1.92                  | 1.33        | 0.17         | 0.17         |
| Cry                | 3.92                  | 1.08        | 0.83         | 0.25         |
| Scream             | 0.08                  | 0.00        | 0.17         | 0.08         |
| Laugh              | 0.75                  | 2.50        | 2.00         | 0.58         |
| Vocalization       | 7.17                  | 9.92        | 11.50        | 1.75         |
| Syllabic Babble    | 0.00                  | 1.67        | 1.50         | 0.00         |
| Word Approximation | 0.00                  | 0.00        | 2.50         | 0.33         |
| Jargon             | 0.00                  | 0.00        | 2.00         | 0.33         |
| Verbal Behavior:   |                       |             |              |              |
| Single Word        | 0.00                  | 0.00        | 2.17         | 7.25         |
| Word Combination   | 0.00                  | 0.00        | 0.67         | 4.92         |
| Connected Speech   | 0.00                  | 0.00        | 0.33         | 16.75        |
| Question           | 0.00                  | 0.00        | 0.00         | 2.33         |

recorded among mothers of children in their second or third year. Among the children, vocal behavior was more commonly heard. Vowel vocalization was the most frequently observed aspect of vocal behavior for all four age groups. Whimpering and crying were not uncommon in the first six months, but were rarely observed by the third year. Syllabic babble, which occurred only between six months and two years was not often used. Word approximation and jargon appeared in the second year, but together occurred on less than five percent of observations.

Neither the quantity nor the type of the mothers' verbalization varied to any great extent with the age of the children. The order in which items ranked, from most to least frequent, was simple sentences, questions, single words, phrases and complex sentences. The children in the second year had begun to talk in single words. Only a few examples of word combinations and connected speech were noted before the third year, by which time the latter aspect was predominant.

Mothers frequently related what they said to the ongoing situation especially with older children. Indeed with children in their third year, 80 percent of mothers' utterances were comments or questions on objects or events in the immediate environment. The speech of both mothers and children included expressive cues such as marked stress and exaggerated intonation patterns on about 20 percent occasions.

Mothers rarely imitated or attempted to expand their children's utterances even when the children were producing single words, word combinations and connected, but incomplete, speech patterns. Among children aged 14 to 36 months a total of 413 verbal utterances were observed yet only ten expansions were noted in response to utterances produced by children in this age range. Only 8.5 percent of the children's utterances were whole or partial imitations of their mothers' speech.

## DISCUSSION

Verbal communication emerges from a rich variety of antecedent behaviors. In this attempt to quantify some of these behaviors we chose to study thirty aspects of communication, of which about half were vocal or verbal. By means of time sampling, we were able to determine the relative frequency with which they were used among Canadian middle class mothers and their children aged between one and 36 months.

### First-Born Children, First Year

Many of our findings were predictable. For example, the high frequency of communication between mothers and their first-born children, particularly those in their first year (Rubenstein, 1967) and the high incidence of facial expression among three-month old babies and their mothers (Ambrose, 1961). Since this approach to the study of early communication had not previously been attempted, it is not surprising that some unexpected results emerged. For example, we found that mothers of one-month old babies talked as much to them as did mothers to children aged two or three years, that mothers used complex sentence forms with almost equal frequency regardless of the age of their children and that they related what was said to ongoing events, thus providing their children with opportunities to derive meaning through context. We also found that mothers made much less frequent use of expansion than might have been expected from the work of Brown and Bellugi (1964) and much less gesture than required to support the notion that verbal language grows out of gesture, a concept which McCarthy (1965) reported as being widely accepted. We observed very little use of gesture by either mothers or children and none among children prior to their use of word approximations.

### Time-Sampling Method

The time-sampling method is clearly not suited to the study of behaviors which cannot be categorized as present or absent during a brief observation interval, behaviors which

cannot be rigorously specified before observations are undertaken or interactions between subjects which involve the detailed (and hence lengthy) analysis of sequences of events. Thus while the frequency with which mothers used complex sentences could be measured in this study, the actual type of phrase structures employed could not be specified. Such specification would require syntactic analysis of mothers' utterances of the type recently undertaken by Snow (1972) and by Phillips (1973).

In time-sampling studies, the presence of observers tends to influence the behavior of subjects as does the presence of tape recorders or cameras; and selection of items for checklists presents problems akin to those involved in selecting portions of taped or filmed material for analysis. Indeed, all methods of observation have advantages and limitations and, as mentioned earlier, these have been extensively reviewed by others. While time-sampling precludes in-depth analysis of behavior, it allows the observer to focus on several simultaneously occurring aspects of a complex problem and to

observe their relative frequency. This is by no means a trivial advantage. This time-sampling study provided a considerable body of data on the relative frequency with which all eight modes of communication were employed by the 48 mother-infant pairs. Further such studies are required to provide normative data, trace the growth of communication skills of normal infants raised in various social milieux, determine what deviant patterns occur among handicapped children such as those suffering from hearing impairment, mental retardation or autism, and to measure the effect of rehabilitation treatment of such groups, particularly if treatment involves parent guidance. Work with the checklists devised for this study has already demonstrated that the frequency with which severely hearing-impaired children and their mothers employ the eight modes of communication differs significantly from that of the subjects observed in this study (Ling and Ling, 1972). The writers have also used these checklists to evaluate and restructure an aural rehabilitation program for hearing-impaired infants and their parents.

## APPENDIX

### Items included in the checklists

Items marked (m) appeared only on the checklist used in observing the mothers, those marked (c) on the checklist used in observing the children and those marked (b), on both. Definitions are given where items, as labeled, are not self-explanatory.

#### A. Vocal Behavior

|                    |                                                                                             |
|--------------------|---------------------------------------------------------------------------------------------|
| Whimpering         | (c)                                                                                         |
| Crying             | (c)                                                                                         |
| Screaming          | (c)                                                                                         |
| Whispering         | (m)                                                                                         |
| Laughing           | (b)                                                                                         |
| Vocalization       | (v): non-crying vowel or vowel-like sounds with only occasional consonants.                 |
| Syllabic Babble    | (b): syllables, usually repetitive, consisting of both vowels and consonants, e.g. "agaga." |
| Word Approximation | (b): incomplete words, e.g. "nana" for "banana."                                            |
| Jargon             | (c): nonmeaningful flow of syllables with speech-like rhythm and intonation.                |

#### B. Verbal Behavior

|                      |                                                                               |
|----------------------|-------------------------------------------------------------------------------|
| Single Word          | (b): distinct word used in isolation.                                         |
| Word Combination     | (c): two or three related words, e.g. "baby fall."                            |
| Connected Speech     | (c): meaningful flow of several distinctly spoken words.                      |
| Phrase               | (m): syntactically correct part of sentence, e.g. "in the car."               |
| Simple Sentence      | (m): syntactically correct sentence.                                          |
| Complex Sentence     | (m): sentence containing subordinate clause.                                  |
| Question             | (b): verbal question with appropriate word order and intonation.              |
| Imitation            | (b): repetition by child of what was said by mother, or vice versa.           |
| Reduction            | (c): partial imitation of spoken structures.                                  |
| Expansion            | (m): elaboration by mother of child's spoken structure.                       |
| Expressive Cues      | (b): marked stress or exaggerated intonation.                                 |
| Related to Situation | (m): verbal reference to ongoing activities or events, or to objects present. |

- C. Eye Contact (b): communicators look directly at each other's face (eyes appear to meet).
- D. Facial Expression
- Positive (b): e.g. smiling
  - Negative (b): e.g. frowning, grimacing.
  - Mouthing (b): lip, mouth or tongue movements in the absence of vocalization.
- E. Body Posture
- Positive (b): movement of body, head, limbs or trunk towards partner; physical contact, arm around partner, holds hand.
  - Negative (b): movement away from partner; resists physical contact; becomes rigid; hits, kicks or grabs.
- F. Action (b): physical manipulation of objects in interaction with partner, e.g. gives object on request, tugs mother's clothing, dresses child, plays games with partner.
- G. Demonstration (b): pointing or glancing to indicate object or person.
- H. Gesture (b): e.g. shaking or nodding head, beckoning or acting a sequence of events.

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# COMMUNICATION DEVELOPMENT OF NORMAL AND HEARING-IMPAIRED INFANTS AND THEIR MOTHERS \*

Informal Presentation: Agnes H. Ling and Daniel Ling

## OBJECTIVE

Our interest in communication development in normal children in the first three years of life came through working with very young deaf babies and their parents. We were trying to promote more normal development of language through early intervention and we felt that we had to look more closely at how communication develops in normal-hearing babies.

## Method

First we had to find a method that would give us quantitative data. There are very many observational studies in the literature, particularly of mothers and their very young infants in the first month. However, there does not seem to be anything that provides information about the extent to which modes of communication are used at different times during the period from birth to three years--at which point the child is essentially verbal and able to communicate very much in the way that adults do.

The method that appealed to us most was time sampling, which was used by Rheingold (1961) to study caretaker behavior. This seemed a possible approach and we developed

our own checklist. We decided on the different modes of communication that we wanted to measure and on individual items that concerned us most within each mode. Using clip boards, checklists, rulers and a stop watch, we observed and recorded whatever communicative event occurred during every 30th second over a period of 50 minutes. After practice on quite a large number of trial cases, we modified the list so that we could obtain exactly the kind of information that we wanted. We then trained two observers until their results agreed at a level of better than 90 percent. One was then assigned to observe and record the mother's behavior; the other, the child's.

## STUDY OF NORMAL-HEARING INFANTS AND THEIR MOTHERS

### Subjects

We studied four children at each age level. They were a firstborn boy, firstborn girl, lastborn boy, and a lastborn girl. We chose six age levels, from 1 to 11 months, in the first year; 14, 18, and 24 months in the second; and three levels in the third year, as being reasonably representative of developmental stages. The modes we studied were vocal behavior, verbal behavior, eye contact, facial expression, body posture, action, demonstration, and gesture. Having followed the conference here I am much more aware that many of these checklist items actually involved the visual modality. I had not realized this so vividly before.

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## Test Environment

We were naturally much more interested in vocal and verbal behavior, so these categories contained many more items than the others. We did the observing in the child's home rather than in our clinic. We felt that it was an intrusion in the first place to have one or two observers watching what goes on between a mother and a young child, but that the least unnatural situation would be if we worked in the child's own home. The mothers were told that we were studying child development and were interested in the different things that babies did at different stages. There was no mention made about the mother having any part in the study. We explained to the mother in advance that the observers would not interact, that they would keep their eyes more or less on the paper, and if the child were old enough to approach there would be no interaction whatsoever. Previous workers had found that if you do not respond to a child, he will ignore you and find something else to do. All the same, having observers does mean the situation is somewhat unnatural. We cannot assume that what we find with observers present is what would happen if they were not there. We wonder whether the very limited amount of negative behavior observed reflected the mothers' and children's awareness of observers. Certainly the mothers did not scold the children and the children rarely used negative forms of behavior.

## FINDINGS

We found that mothers communicated significantly more often with the firstborn than with the lastborn children. This special treatment was not reflected in the total quantity of communication used by firstborn children as compared with lastborn, although the former vocalized more than the latter.

We found few differences between boys and girls. In fact, the only significant difference was that mothers used more body contact with their sons.

As Figure 31 shows, we found that mothers did not use vocal (pre-

verbal) behavior very much to their children but rather tended to talk, that is use the verbal mode. When they did vocalize, they did so more often to the younger baby. Neither the quantity nor the type of the mothers' verbalization varied to any great extent in relation to the age of the children. In other words, there is no difference in the amount a mother talks to a very young baby and the amount she talks to an older baby; but the verbal mode accounts for a greater proportion of communication with older children than with younger.

## Early Months

In the first month the mother uses an enormous amount of body contact but it tends to be accompanied by communication in at least one other mode. Children with hearing loss naturally rely a lot on vision and we wanted to find out how frequently eye contact occurred in normal children. We found that over the period of three years, children and mothers used much the same amount of eye contact, but the greatest proportion was noted among very young babies who relied primarily upon this mode and on facial expression to communicate. These observations suggest that a blind baby is going to be at a considerable disadvantage, even during the first months.

Our results relating to the use of facial expression by children closely agree with studies of smiling. We found babies' use of facial expression as a means of communication to peak at three months, when smiling most frequently occurs. Mothers of firstborn and younger babies smiled most often.

Action was found to be a major means of mother-to-child communication, particularly in the first year of life. Blind children obviously miss a great deal in this respect because they do not see what the mother is doing.

## Gesture

We saw very little use of demonstration or gesture by either mothers or children, in spite of many

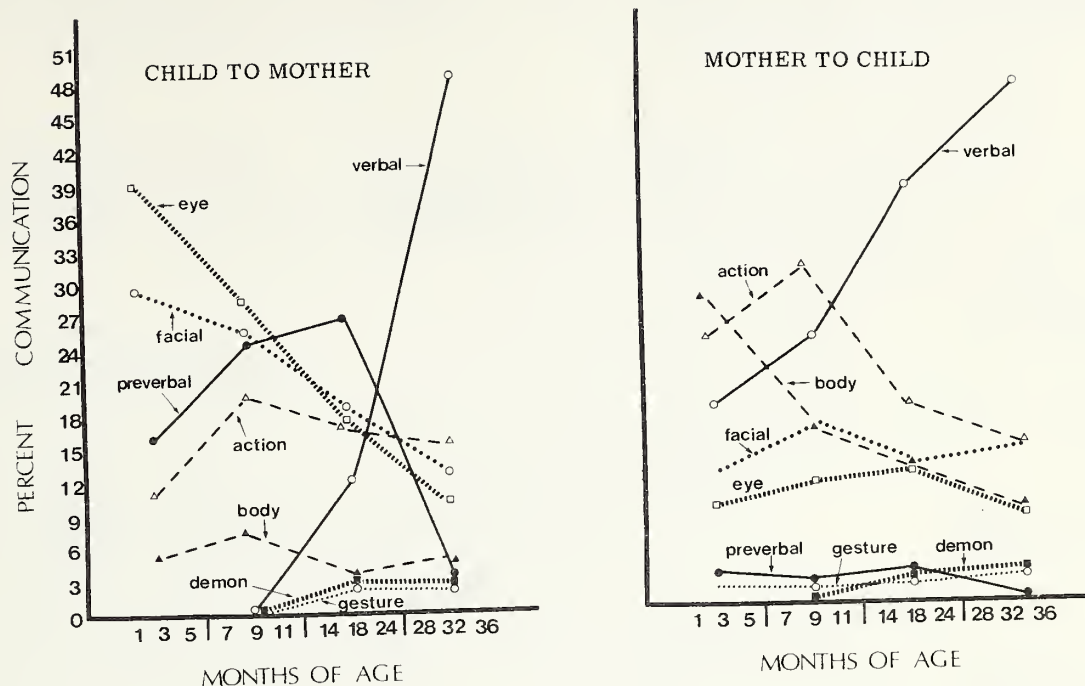


Figure 31. Modes of Communication Employed Between Children and Mothers and Between Mothers and Children in Relation to the Age of the Infants.

suggestions in the literature that verbal communication grows out of gesture. In fact, gesture did not occur except with children who had reached the level where they were using their first words. Results suggest that children move from the vocal mode, which they use increasingly through the first two years, directly into the verbal mode.

#### Age Groupings

To present results graphically, our data was regrouped by pooling observations across three age levels (1, 3 and 5 months; 7, 9 and 11 months; the second year and the third year). The percentage communication in the various modes rather than the actual absolute quantities observed are presented here. A more detailed presentation is provided by Ling and Ling (1973).

#### Verbal Behavior

When recording items of verbal behavior (words, simple sentences, and complex sentences), we also noted whether the mother or child imitated one another, whether the mother expanded on the language the child had used, and whether she spoke in relation to the situation (see Table 14). Out of the 2,400 observations on mothers of children at the 14-36 month level, we found only 20 examples of imitation. Children in these age groups were seldom observed to imitate what the mothers said. In fact, only 35 imitations or attempts at imitation (reduction) were noted in the 2,400 observations. The number of occasions on which mothers used expansions with children in the same age range totaled only ten. This finding contrasts starkly with the 30 percent expansions noted in the mothers studied by Brown and Bellugi

TABLE 15

Frequency of Occurrence of Specific Vocal and Verbal Items Observed in Mother to Child, and in Child to Mother Communication. Each Cell Represents the Total Number of Events Recorded During 1200 Observations of Normal Hearing Children (12 Children / Group x 100 Observations / Child).

| Child's age<br>in months . . . . . | <u>Mother to Child</u> |             |              |              | <u>Child to Mother</u> |             |              |              |
|------------------------------------|------------------------|-------------|--------------|--------------|------------------------|-------------|--------------|--------------|
|                                    | <u>1-5</u>             | <u>7-11</u> | <u>14-24</u> | <u>28-36</u> | <u>1-5</u>             | <u>7-11</u> | <u>14-24</u> | <u>28-36</u> |
| <u>Vocal Behavior</u>              |                        |             |              |              |                        |             |              |              |
| whimper                            |                        |             |              |              | 23                     | 16          | 2            | 2            |
| cry                                |                        |             |              |              | 47                     | 13          | 10           | 3            |
| scream                             |                        |             |              |              | 1                      | 0           | 2            | 1            |
| whisper                            | 30                     | 18          | 4            | 12           |                        |             |              |              |
| laugh                              | 6                      | 9           | 4            | 7            | 9                      | 30          | 24           | 7            |
| vocalization                       | 68                     | 32          | 24           | 3            | 86                     | 119         | 138          | 21           |
| syllabic babble                    | 2                      | 6           | 4            | 1            | 0                      | 20          | 18           | 0            |
| word approximation                 | 0                      | 2           | 0            | 0            | 0                      | 0           | 30           | 4            |
| jargon                             |                        |             |              |              | 0                      | 0           | 24           | 4            |
| <u>Verbal Behavior</u>             |                        |             |              |              |                        |             |              |              |
| single word                        | 92                     | 74          | 78           | 60           | 0                      | 0           | 26           | 87           |
| word combination                   |                        |             |              |              | 0                      | 0           | 8            | 59           |
| connected speech                   |                        |             |              |              | 0                      | 0           | 4            | 201          |
| phrase                             | 64                     | 69          | 51           | 53           |                        |             |              |              |
| simple sentence                    | 119                    | 101         | 124          | 123          |                        |             |              |              |
| complex sentence                   | 11                     | 12          | 25           | 54           |                        |             |              |              |
| question                           | 106                    | 108         | 84           | 121          | 0                      | 0           | 0            | 28           |
| imitation                          | 7                      | 8           | 10           | 10           | 0                      | 1           | 4            | 17           |
| reduction                          |                        |             |              |              | 0                      | 0           | 7            | 7            |
| expansion                          | 0                      | 0           | 1            | 9            |                        |             |              |              |
| expressive cue                     | 55                     | 34          | 48           | 55           | 0                      | 0           | 29           | 56           |
| related situation                  | 131                    | 227         | 251          | 319          |                        |             |              |              |

(1964). We found that the number of occasions on which the mother's speech was related to the situation increased throughout the three-year period, so that by the time the child was well into a language learning stage, the mother was relating practically everything she said to the situation. This finding suggests that the situation provides meaning which is important for the child in learning language. But blind children must have reduced cues as to the meaning of situations which are not visible to them.

## COMMUNICATION MODES BETWEEN MOTHER AND HEARING-IMPAIRED INFANT

### Pre-Training

Figure 32 gives an example of the communication modes used by a mother to her young deaf child prior to training. Modes used by mothers of normal hearing children of the same age are also shown in this figure. We find that the mother talks much less than expected to her hearing-impaired child. She also uses much less body contact. Eye contact and action are her main means of communication.

Figure 33 shows the child's behaviors for the same period. The child does vocalize, but the individual items recorded are crying, laughing, and vowel vocalization. There are no syllables present, nothing that sounds like ma-ma-ma or da-da-da. Perhaps this is the reason that the mother became discouraged, for a baby would normally be saying ma-ma and da-da from six months old.

### Post-Training

Figure 34 illustrates the situation after 17 months' training. Here you see that the mother has really altered her means of communication with the child. She is communicating verbally. This child is now using his residual hearing and the mother is being reinforced for her efforts. If you look at the child's behavior (Fig. 35) you see that after 17 months, preverbal communication has really increased enormously and is much more like that of the younger

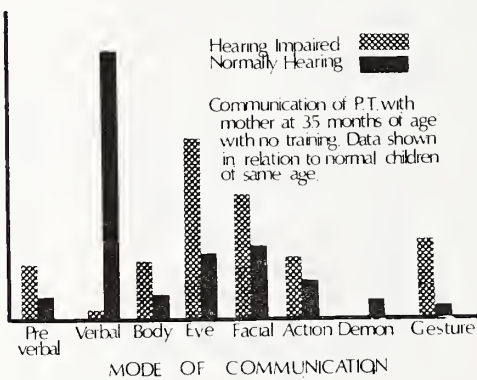
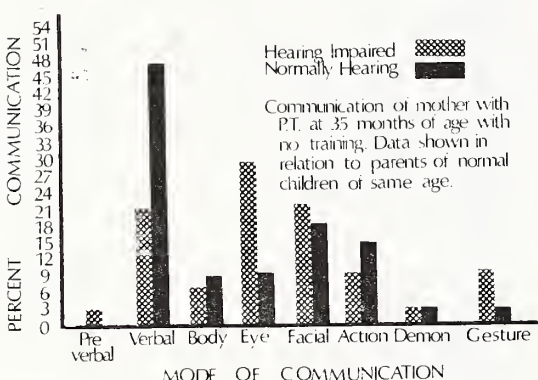
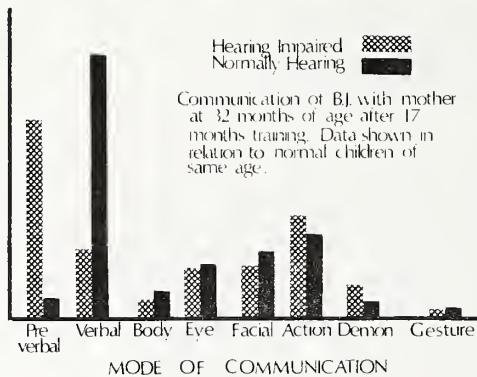
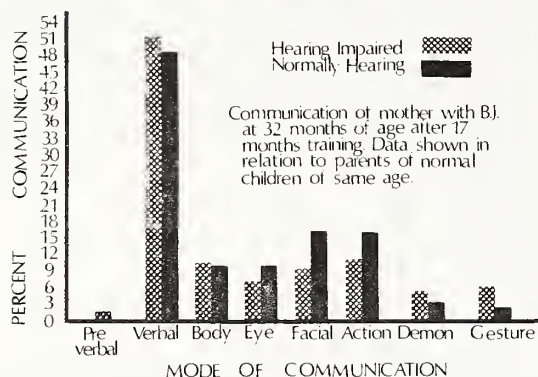
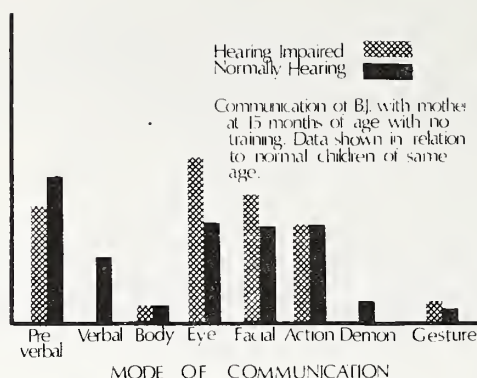
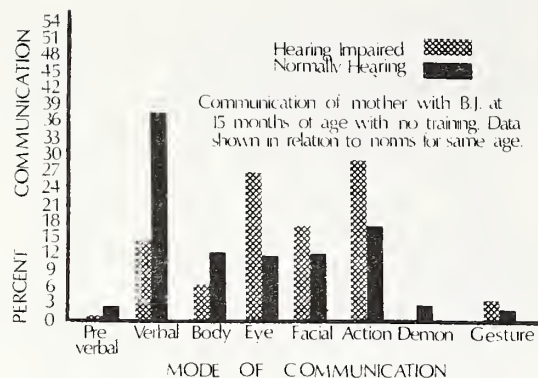
baby. The items no longer consist of just crying and laughing. Now there are syllables and word approximations which, though not clear enough to be considered verbal, are very much more speech-like. The percent of verbal communication indicates a good beginning but at this stage it probably consists of a few words that the child uses over and over again. The gesture level may seem very low for a hearing-impaired child. I think this is partly because of the type of training. We put great emphasis on an auditory approach. We do not discourage gesture but we certainly do not encourage it. Also we were dealing with a very intelligent and able mother. At the time this paper is being presented, the child has reached age five and is attending a regular school.

### Age

Figure 36 shows an example of a mother's communication with an older, profoundly hearing-impaired child. The data presented here was collected when she was identified as hearing-impaired at 35 months of age. The mother does talk to the child but there is very much more visual communication and gesture than we found among mothers of normal-hearing children of the same age. Figure 37 shows that this child uses a much larger amount of gesture than hearing children of 35 months. Intelligent, older hearing-impaired children with poor oral skills tend to develop gesture to a high level. It may even account for up to 50 percent communication by age five. Figure 37 also shows that visual communication was predominant prior to training. Vision must, of course, always play a large part in the oral education of profoundly hearing-impaired children since lipreading must be used as a supplement if only limited residual hearing is available. Vision is also required if manual means of communication (fingerspelling and signing) are used to supplement lipreading and the use of hearing.

### Multiple Handicaps

While we recognize that a few multiple-handicapped hearing-impaired children may need to be taught using



# Modes of Communication Used by Two Deaf Children and Their Mothers in Relation to Age and Training

Figure 32. Top Left.

Figure 33. Top Right.

Figure 34. Middle Left.

Figure 35. Middle Right.

Figure 36. Bottom Left.

Figure 37. Bottom Right.

manual means of communication, our aim is to enable most hearing-impaired children to compete and conform in a hearing world. We therefore concentrate on the development of speech communication skills. Such

skills can generally be taught to hearing-impaired children with visual problems, but the task is much harder. Perhaps more frequent meeting of specialists in the area of vision and audition might lead to more effective means of helping such children.

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Discussant: Bernard Z. Friedlander\*

My specialty is receptive language development. Listening to audiotapes of language interaction in the home, it becomes utterly astounding how children can organize a language system from what can only be called "verbal garbage." For example, if you listen to a foreign language, you have a great deal of difficulty dividing up the stream of speech into lexical units; and, if intonational patterns are substantially different from English, you also have a great deal of difficulty interpreting the intonational pattern. When you realize that a baby is learning what is, in effect, a foreign language, you recognize the enormously difficult problem he faces in just extracting the signal from a very messy auditory background.

#### CONCEPTUAL ORGANIZATION OF LANGUAGE

With this primary problem for the normal *sighted* child in mind, some of the best current thinking generally regards the basis of the conceptual organization of language learning in such a way that the coding system starts off with the representation of concrete, everyday objects and events. If a child cannot see these objects or watch these events taking place, he is bound to have a desperately difficult problem organizing them into coherent patterns of meaning and reference for an initial coding system.

I would have inferred that the blind child not endowed with any special blessing of intelligence would be delayed in his language growth.

Specialists tell me that it is not so. If that is true, all of the explanatory systems now on the books

tend to fall apart with the possible exception of Lenneberg's. However, I disagree quite substantially with this viewpoint and with the Chomsky viewpoint of innate mechanisms. I think the only innate mechanism is intelligence and integrative competence. There is no explanatory mechanism of how blind children learn language, especially in light of the Lings' data showing how the normal child's experience in language is simply saturated and supersaturated with visual experience.

#### TRAINING FOR INTERVENTION

A point I would like to emphasize is the enormous impact of thoughtful systematic intervention and training suggested by the interactions between the deaf children and their mothers. These children were not totally deaf. However, the parental environment had failed to produce any intuitive "maternal instinct" for mobilizing the child's residual capability so as to maximize their developmental options. I am sure that this is just as important in the field of the blind as of the deaf: one cannot count upon the course of nature in a mother-child relationship to provide the necessary intervention for children who have disabilities.

I remember hearing several years ago about families who made no effort to accommodate to the needs of a deaf child with a hearing aid. The parents made no effort to turn radios down or to reduce the background noise level. These were not bad parents, and it is not that they did not love their children. They just didn't know the children's real developmental needs. There is no question but that there is a tremendously important role for professional assistance in enriching the home life of children with such disabilities. These children need a great deal of supportive assistance to achieve optimal adaptation. While parents and families may have the intuitive skill to adjust and adapt to the child's

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emotional requirements, I think it is a mistake to assume that some intuitive instinct on the parents' part will automatically come to the

aid of a child who has special needs. The graphic presentation of the data in this paper did a superb job of demonstrating this.

## General Discussion

### PARENTHOOD TRAINING

Dr. Prescott concurred with Dr. Friedlander on the need to train for parenthood. In showing the film "Rock-a-bye Baby" to high school students, the most common responses were one--they did not know that it was so important to stimulate the sensory systems of the infant and child, and two--they really did not know that it was so important to hold and touch the child. In other words, the concept of mothering is not instinctive. It is something that has to be learned, and is not intuitive. Dr. Friedlander added that the notion the mother is somehow equipped with intuitive knowledge which helps her give the child what it needs is imbedded in the mythology of the culture. The child care professions by and large do not know the hard data that disestablishes the myth of intuitive maternal knowledge of child care. Mrs. Ling's paper presented one more example of the parents' lack of knowledge and consequent inability to respond optimally to the needs of children with special problems.

Dr. Chase, however, questioned whether in the case of the mother who did not speak to her deaf child, this lack of communication might not reflect a high sensitivity in a parent under observation. Talking to a deaf child probably would be the first thing to be inhibited in a parent in the presence of an observer. The parent might think, "how foolish will I look if I talk to this child, because they obviously know he is deaf." It is possible that without an observer, there would be more speaking to

the child. Dr. Elonen added that was true not only in the case of a deaf child, it was a feeling expressed by many mothers of normal-hearing children. Mrs. Adelson commented that this was not so with the deaf child they followed. The mother used generous gesturing and speech. She never stopped talking to the child from 7 months on, although she possibly got back even less than the mother of the 15-month-old child described by Mrs. Ling. Dr. Chase remarked that with the blind children she studied, parents were often much more conscious of tactile experiences when someone was present. She felt this reaction of parents might be a factor.

### INTERACTION

Dr. Berkson stated he would not have been surprised if Mrs. Ling's findings had been the reverse of the ones she had. He pointed out that it is very important not to argue from the single case, but to emphasize an interaction analysis: what the child means to the parent and what the consequences of the parents' behavior are to the child. It is conceivable that depending on the kinds of rewards the child gives to the mother or what her general motivational system is, there could be a reversal of the results. A generalization with respect to deaf children probably has to be analyzed in terms of a broader concept.

Dr. Milburn reported that she and Dr. Elonen observed a hearing child of a deaf mother and a deaf father and four deaf grandparents. The mother

used a simultaneous method of communicating with the child. There were two deaf children in the home and an older hearing child. They observed, and subsequently were able to demonstrate, that this mother was able to elicit responsive behavior from the child by facial or eye contact alone. When the eyes were covered, it was not possible to elicit behavior unless the mother spoke and signed to the child. So at least for this particular child it was necessary to have information from the eye area. This was true also of the mute father, when he interacted with the child.

## INITIATION OF COMMUNICATION

Mrs. Fraiberg brought up the question of initiation of communication. It had been shown that in some instances a preponderance of communication between mothers and children were instigated or initiated by the baby, as often seen on their own videotapes of sighted children. She wondered whether the mother's not getting this might be an important factor in the very small amount of imitation and expansion of sentences reported by Mrs. Ling. Mrs. Ling replied that it was in fact among mothers of normal-hearing (not deaf) children that imitation and expansion of the child's speech was rarely observed. Mrs. Ling also added that they had tried to record whether each communication event was initiated by the baby or by the mother but observer reliability had been inadequate.

## VERBALIZATION

In response to a question from Dr. Fowler, Mrs. Ling recalled some features of the mother's verbal behavior in the normal hearing sample. A high proportion of what the mother said was in reference to ongoing events, activities or objects present, as indicated on Table 14 under the item, "related to the situation." Mothers also tended to provide their children with expressive cues such as exaggerated intonation patterns.

Dr. Fowler explained this was of particular interest to him in relation to the day care program for babies in Toronto. This program is

supplementary to home care. The basic caretaker is still the mother on the weekends and evenings and mornings, but the baby is in day care for 8 to 10 hours a day. The day care staff are variously trained. There are very few sources of training either in Europe or in North America that incorporate psychological concepts of caring for babies, either emotionally or cognitively. This is what they were introducing.

There is an interesting thing about the young women who come into day care for training, many of whom are at the high-school level or slightly above. During the first year, in fact until speech develops, they do not perceive the need to talk to the child. They have no appreciation of the founding of language development and receptive language comprehension. They get no feedback and they feel self-conscious about talking to a baby. It is very hard work to persuade them to do so. The mother in a home situation spontaneously, out of her own needs, seems to do it more; nevertheless a good proportion of mothers are also silent with their babies, and presumably without language input and a model of some kind, this delays language.

A tremendous language development has resulted from efforts to remedy this, both with the mothers and with the day care staff. One of the things he had conceptualized as being extremely important in providing the foundation of language development is the relating of the verbal statements in specific simple terms to objects, and events that the child is experiencing. With the blind child this probably needs to be done through the touching experience and the language statement, focusing first on simple object labeling using nouns, and on events, and then the more complicated modifiers and adjectives and so on.

## PIAGETIAN CONCEPTS

Dr. Parmelee raised another question in language development theory. One of the theories currently in the literature is related to the developmental stages of Piaget. This theoretical position holds that there will not be syntax until there is symbolic solution to a problem. Some Piagetian concepts such as object constancy had

been used in earlier discussions--particularly regarding the paper on motor development--and Dr. Parmelee asked Dr. Friedlander to comment on this view.

## SYNTACTIC COMPETENCE

Dr. Friedlander replied that he felt the theories were probably premature, yet they were valuable. There is a question as to whether a receptive grammar and a receptive competence are the same as, or different from, expressive competence. One is continually amazed at how much the language can be distorted without the children seeming to know the difference. A colleague of his had recently carried out a study with children in the age range of from two to three years. It was not until one got to the most articulate, most advanced three-year-olds that they were able to distinguish that something was wrong when she spoke to them in grossly distorted syntax, with sentences and phrases turned around. Two and two-and-a-half-year-olds right up to the three-year-olds did not seem to pay any attention at all to such differences.

In the light of such information it is hard to know where one stands when talking about syntactic competence of children in this age range and with respect to object constancy. They do interact successfully in a world that is partly linguistic, partly visual, and partly action-oriented. There was a point in Mrs. Fraiberg's paper which he had not mentioned, the transition from an active representation to pictorial representation. Jerome Bruner spoke about this a number of years ago, and Piaget speaks about it in different terms. This does take place, but children are working several systems at once. Dr. Friedlander felt that what occurs is the refinement of single systems over a longer period of evolution than we are presently giving adequate attention to in our efforts to systematize this phenomenon.

Another of his colleagues did a study with kindergarten, first, and second grade children, in which they could operate a switch to one side or another, and they would hear through earphones versions of a story which

were either a normal narrative version or some kind of a transformation of it. In one transformation the syntax was all scrambled up by randomization, with the intonation held normal. It was not until the third grade that they got bright upper-middle class children who could reliably demonstrate a preference for the normal narrative telling of the story. The kindergarten, and first and second grade children could not even describe in a subsequent probe interview what was different about the two versions of the story. When asked, "Did it sound the same if you pressed the switch one way or pressed it the other way?" the children were confused. They were not confused by a task they did not understand, because preliminary studies were done to show that they could handle the task. The input organization is just far less stabilized than we have tended to think in the past. So Dr. Friedlander would not venture to judge the validity of Piaget's concept that a child must have object concept before he can name things, and must have reached Stage 6, where he is internally solving problems before developing his own syntax.

## SPEECH ACQUIREMENT

Dr. Fowler, however, thought there was some good data indicating that this tends to be so. There is no reliably recorded case of a child ever emitting a word, other than perhaps a signal, prior to eight months of age, not even the brightest child on record. There are some anecdotal reports of six months, but nothing reliable. Now eight months or slightly older is the object concept period, Stage 4 of Piaget, when the child really begins to search for the vanished object. So there does seem to be a coordination of the two systems, in which the child must be able to identify the physical existence of an object before he can represent it in terms of a symbol of some kind.

It is interesting, too, that in language development it takes quite a few months before the first few words are succeeded by a rapid acquisition of vocabulary. In fact there is a sort of language lag. Dr. Fowler and a student of his had noticed that when the first hurdle of being able to recognize a particular word or two

as a symbol is mastered, there is a lag of sometimes several weeks before suddenly the whole pattern of how word structures can be put together to label different objects is successfully acquired. Once the system principle for word labeling is mastered words are acquired in rapid succession. Then of course the next problem is syntax.

## LANGUAGE DEVELOPMENT

Dr. Friedlander pointed out that we keep assuming that there is only one mode of language learning. He really thought that this was not so. For example, the first child of a member of his laboratory, was clearly and unarguably a cognitivist. Her second child was clearly and unarguably a Skinnerian. This is not supposed to happen. Children are supposed to learn language all in the same pattern. The first child passed some milestones such as those described, organized clusters of things all at one time, and went through a leap of language learning progressing so fast that the mother could not keep track of it in a systematic fashion. With the other child, until he was beyond the age of three there was never a question in her mind as to where each new word in his vocabulary came from, because it came directly from experiential operant encounters with the environment of the Skinnerian type.

So if in discussing blind children one assumed that there is a single way of cultivating language development, this, in Dr. Friedlander's view, was a mistake at the outset. Some children probably would have a higher likelihood of learning language in a cognitively oriented rapid uptake mode, and some children would require step-by-step encounter and reinforcement experience. He did not know whether this was related to intelligence, and whether it was on a single continuum.

Regarding the Piagetian question, Mrs. Fraiberg cautioned that they had no demonstration that the children at the language acquisition stage had passed Stage 6, in fact she was very sure they had not. However, naming of objects came on schedule. Here they had nothing better than the standard developmental scales to go

by, which are not good. Naming of objects, the first two-word combinations, three- and four- and five-word phrases came on schedule with these children.

However, she thought that there were links between what Piaget would call evocative memory and certain stage in language acquisition that may have been overlooked. A large part of the vocabulary that can be seen in Kathy's two-year sample and three-year sample could be accounted for on the basis of recognition memory alone. Her capacity to evoke experiences in the past or to speak of an object not present in perception is not demonstrated with the same language samples.

It may be that this does need to be explored in reference to a Piagetian scale, and with special attention to the differences between recognition memory and evocative memory to which Piaget himself has drawn our attention.

## BODY CONTACT AS COMMUNICATION

Turning to another aspect of the data presented by Mrs. Ling, Dr. Prescott commented on the great paucity of body contact in general in the modes of communication observed for the normal and the deaf. He thought this reflected the culture that we are all part of. We are a nontouching society. Mrs. Ling agreed. Only mothers of one-month old babies used body-contact as a major mode of communication.

Dr. Elonen mentioned that she had seen a television program on which it was emphasized that the young child should be held. She wondered whether some of this would filter through to the general public. Dr. Fowler commented that in day care, interacting physically and cuddling was emphasized and they encouraged situations where the young people will want to hold and play with the child physically. They found, however, that in the formal system in which they were operating at present day caretakers were caught in a hierarchy of commands issuing from above. If one person in the hierarchy has a certain personality style that tends to exclude her personal physical interaction, then because of the

social organization of the apparatus it is not easy to change this orientation. He did agree that this physicalization was an extremely important aspect of development and the basis for communication.

#### DAY CARE STAFF RATIO

Asked by Dr. Prescott what he would consider an optimum staff-child ratio in a day care center, Dr. Fowler replied that he had formulated this on the basis of experience and in relation to developmental criteria of increasing mobility and cognitive abstraction. Up to a year, roughly, he would say one to two, and from one year to about 20 or 24 months, one to three, and then from two years on up, you can have one to four or five. Toilet training is a critical turning point, going from the second to the third stage.

#### OLDER CHILD AS CARETAKER

Dr. Friedlander commented that some might see this as a fantastic personnel structure being developed, if one-year-old babies are to be handled with one caretaker to every two babies. It is a higher rate of adult care than in a family of three or four children. Dr. Fowler pointed out, however, that in a large family, one tends to find spacing of children,

so that there are some older siblings caring for the younger. A very logical solution, and one they were trying to get the government agencies to support, would be to take high school students, perhaps even younger, and bring them in as a natural alliance. The high school students need experience with child development and socialization through direct contact, and the babies need lots of spontaneous loving care, physical activity and so on. The two together work beautifully. Dr. Friedlander agreed that it was a natural alliance, but it involved reshaping society, and there would be a lot of objection to it.

Dr. Elonen also cautioned that the older children when taking care of the younger sometimes act as if the younger child were a doll, and therefore do everything for the child. The child can then become very passive and fail to get as much activity and experience as it should. Dr. Fowler agreed that this was a tendency of some older children, so that they could not be simply thrown together without making the older child aware of the need to focus on autonomy. This as well as cooperation was a critical concept for the babies. Not to do for, but to interact with them and watch the ongoing processes of the child. To facilitate, but not to intrude or dominate.

## TEMPERAMENT AND THE RUBELLA CHILD

Formal Presentation: Stella Chess and Paulina Fernandez\*

In the course of our behavioral study of children with congenital rubella it has become clear that in making plans for multihandicapped children the temperamental aspects of the child's behavior require identification. Programs which appear ideally suited to a child's needs based on the presence, degree and severity of visual loss, hearing defect, and/or cognitive deficit may come to failure because the child's temperamental pattern makes them inappropriate for him. Yet there are other children in whom the temperamental qualities are such that they can respond optimally to the training and social milieu.

If temperament is a determining factor in management and educational plans for multihandicapped children, logically, it should be identified before making definitive plans and should take an equal place in the list of factors to be studied in arranging to meet the needs of the youngster.

### DEFINITION

Before discussing the relationship of temperament to the behavior of rubella children, it is appropriate to define the concept of temperament as used by the authors. The term *temperament* as used here refers to *the style which characterizes the behavior of an individual*. It is the

*how* of behavior as contrasted with the *why* or motivation and the *what* or content of actions. These specific reactive characteristics which give behavioral individuality are easily recognized in global terms both in normative and abnormal behavior patterns. We all know individuals whose actions are characterized by immediate enthusiasm and intense but short-lived involvement and others who are typically cautious about entering new situations. Once they make up their mind, they can be counted on to follow through.

The initial studies were done on two normative groups of children selected at birth; one from middle class families, the other of working class Puerto Rican background. From the periodic interviews, observations and tests a number of concepts have emerged. Nine temperamental qualities have been identified during infancy and their effects on parent-child interaction and in determining the nature of the child's experiences have been studied.

Through inductive content analyses of the infant behavior protocols it was possible to characterize the individual behavior style of each child in the study in terms of nine categories of reactivity. These qualities, which were defined when the child was only two to three months of age, can also be identified at all subsequent age periods in infancy and childhood. The nine categories of reactivity in which temperamental attributes are subsumed are:

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1. *Activity Level*: the motor component present in a given child's functioning and the diurnal proportion of active and inactive periods. Protocol data on the child's motility when he is being bathed, fed, dressed, and handled; as well as information concerning his sleep-wake cycle and his reaching, crawling, walking, and play patterns are used in scoring this functional category.
2. *Rhythmicity (Biological regularity)*: the predictability and rhythmicity and/or the unpredictability and arrhythmicity in time of any function. This is analyzed in relation to the child's sleep-wake cycle, his hunger or feeding patterns and his elimination schedule.
3. *Approach-Withdrawal (positive-negative initial responses)*: the nature of the child's initial response to a new or altered stimulus, be it a new food, a new toy, or a new person, is scored.
4. *Adaptability*: the nature of a child's responses to new or altered situations with respect to the ease with which they are modified in a desired direction, irrespective of the initial response is scored.
5. *Intensity of Reaction*: the energy level or vigor of a child's response, independent of its direction, is scored. (Either a negative or a positive response can be mild or intense.) Responses to stimuli, to pre-elimination tension, to hunger, to repletion, to new foods, to attempts at control, to restraint, to dressing, and to diapering all provide scorable items for this category.
6. *Threshold of Responsiveness*: the intensity level of stimulation that is necessary to evoke a discernible response, without regard to the specific form that the response may take or the sensory modality affected, is scored. The behaviors used are responses to (a) sensory stimuli, (b) environmental objects, and (c) social contacts.
7. *Quality of Mood*: the amount of pleased, joyful and friendly versus the amount of displeased, crying and unfriendly behavior is determined; i.e. does the child show more smiling and laughing or more fussing and crying behavior?
8. *Distractibility*: the ease with which a child can be diverted from an ongoing activity by extraneous peripheral stimuli is rated.
9. *Attention Span and Persistence*: these two categories are related. Attention span is the length of time a particular activity is pursued by the child. Persistence refers to the continuation of an activity by the child in the face of obstacles to the maintenance of the activity direction.

## SIGNS OF THE DIFFICULT CHILD

The relationship between single and clustered temperamental qualities and the development of behavior disorders has been examined in the normative group, in a sample of mentally retarded children and in 243 children with congenital rubella. In the initial study it was found that a particular cluster, high irregularity, predominance of withdrawal responses to new stimuli, slow adaptability to change, predominance of negative mood and high intensity of reactions, placed a child at the greatest risk of developing a behavior disorder and we termed these particular temperamental attributes *signs of the difficult child*. An example of a *difficult child* in functioning terms may help convey the meaning of this phrase. One such infant in the New York Longitudinal Study showed his biological irregularity by irregular and unpredictable sleep patterns which made for great difficulties in his mother's ability to plan and complete her household chores. Both parents found themselves woefully short of sleep and patience many mornings. Evacuations were also irregular--when toilet training time arrived it was impossible to determine what hour of the day would be best for the introduction of the potty. There was slow acceptance of new foods, with first response to a new taste frequently consisting of loud crying, arching of the back, flinging of the

arms and legs, turning the face away and spitting out the food--a sequence not calculated to increase a young mother's confidence in her nurturing capacities. Representations of the child's negative mood and intensity of reactivity were to be found in the frequent and loud crying periods evoked either by no obvious stimulus or by the approach of a stranger, a sudden or new sound, or the alteration of a routine.

In our study of mentally retarded children, it became evident that signs of the difficult child were even more crucial and held a higher risk in this group with mental retardation than in children with normal intelligence. Since there are fewer educational and social options open to the cognitively handicapped as opposed to the intellectually normal child, such negative aspects of temperament assume even greater importance. The same reasoning would apply to multihandicapped children.

Two other aspects of the New York Longitudinal Study are relevant. One is the concept of consonance and dissonance in enhancing or decreasing positive behavioral adaptation. This concept has been worked out with the middle-class children demonstrating that there are possibilities of child-parent dissonance in each temperamental attribute that can lead to behavior disorder.

The terms "consonance" and "dissonance" and the concepts behind their usage here are borrowed from the evolutionary concept of *goodness of fit* (L. J. Henderson, 1913). As considered in this framework, the organism's functioning is dependent on the degree to which the environment provides properties which are consonant with the organism's characteristics. Conversely, if there are dissonances between the organism's style and characteristics of functioning and the properties of the environment, sub-optimal development will result. It is important to note that consonance does not imply a maintenance of the equilibrium but rather that demands for reorganization of functioning should occur in a manner which facilitates orderly and progressive advancement by the organism. Dissonant environmental demands produce excessive stress and result in a disordered

or retrogressive direction of development. We have also found that, with identification of a child's temperament, parent guidance can often alter parent attitudes and child care practices toward a consonant and positive child-parent interaction. A second analysis which is pertinent to the concerns of the development of multihandicapped children has to do with the relationship in both intellectually-normal children and mentally-retarded children, between temperamental qualities and school behavior, and academic success or failure.\* This has been reported previously.

## TEMPERAMENTAL IDENTIFICATION

With this background, let us report to you some of what we have found so far regarding temperament in the 243 children with congenital rubella whom we have studied behaviorally and developmentally.

Temperamental identification of the rubella children was determined by using the same interview protocol concerning the child's daily activities as had been used in the other temperament studies described above. They were scored in accordance with the identical definitions and by the same scorers. It was found that there were no significant differences in the frequency with which five, four, three, two, one or none of these signs appeared in our rubella population as compared with both the New York Longitudinal Study and the retarded youngsters. However, it was found that 73 percent or almost three quarters of the youngsters with four or five signs of the difficult child had behavior disorders and slightly more (three-fourths or 77 percent) of those with zero or one sign had no psychiatric disorder. Thus, there was a clear linkage between certain temperamental traits and the development of behavior disorders in this population.

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\*S. Chess, "The Influence of Temperament on Education of Mentally Retarded Children," *The Journal of Special Education*, 1970, 4(1); S. Chess, "Temperament and Learning Ability of School Children," *American Journal of Public Health*, 1968, 58, 2231-9.

In addition, we found that four or five signs of the difficult child were found in the rubella children with physical defects three times more often (32 percent vs. 10 percent) than they were in physically-intact rubella youngsters. Thus rubella children with physical defects have a greater temperamental risk for the development of behavior disorder than children whose congenital rubella did not confer physical damage. In fact, we found that more than half the children with physical defects are at high risk for the development of behavior problems, whereas only about one-sixth of the children without defect are at high risk.

Such research numbers and terms are of course composite statements that do not give a real picture of the individual children whose development and adaptation concerns us all. Research conclusions are useful in informing us whether an individual child's problems are in line with an overall pattern or are a departure from it. More than that, however, they can give group trends whose conceptualization can point the way toward individual solutions and strategies.

## INDIVIDUAL CASES

Let us start, however, with an individual case.

Theresa, age five, has moderate deafness as a result of congenital rubella. Her degree of hearing loss was established at age 12 months and she has been attending a school for the deaf since age 24 months. Many factors have contributed to this child's positive response to the program in which she has been placed. Her deafness has only a peripheral component and with her hearing aid she is alert to sounds and is developing speech at the same rate as children deaf from other causes. She has above average intelligence and is capable of age-appropriate cognitive responses. To these assets we must add Theresa's temperamental attributes which fall into the cluster of "the easy child." Her mood is characteristically positive, she has been biologically regular since birth, she approaches new situations with ease and adapts quickly both to changes in

schedule and also in the demands made upon her. Her responses are characteristically of moderate intensity and her activity level is also in the median range. She has average degree of distractibility and persistence while her attention span is long.

Marie, age five, was identified as having a hearing defect of unknown etiology at age 10 months. There is also internal strabismus noted at age 16 months which is partially corrected by glasses. Although she has attended a school for the deaf since age three years, she isn't benefitting from the program and her behavior in the classroom is in marked contrast to that of her classmates. Marie usually refrains from participating in the group activities or if she does join in, will not await her turn or takes objects from the others or pursues the activity after its conclusion. Her precise degree of hearing loss has never been ascertained since her responses to testing and to hearing aid are erratic. Her willingness to perform standardized nonverbal tasks was also erratic. On the basis of those test items which Marie attempted, such as puzzles and figure drawing, and her use of toys, her visual motor capacities and cognition are at least average. She has not built up the degree of word usage of her school companions although under stress and high motivation she can use approximately 50 to 100 words--such as "please" when she wants something.

Because of the erratic nature of Marie's responses to aural stimuli, the possibility of a central organic language defect must be considered. One must also add the factor of temperament to the assessment. This youngster qualifies for categorization as a temperamentally "difficult child." Biologically irregular, she has always withdrawn from new situations and alterations in the demands made upon her and has adapted slowly. Mood has been variable with intense negative reactions evoked by prohibitions. She is persistent, showing this persistence in the pursuit of her own goals--thus either defying the structure around her or seeking out some individual to give permission for her violation of a prohibition (thus proving her awareness of the fact of prohibition).

These temperamental qualities have contributed significantly to the failure of the school curriculum to add to Marie's level of functioning. At home, with one-to-one maternal training she has mastered visual motor tasks whose accomplishment the child has never permitted the school to observe.

Nicholas, age seven, has attended a school for the deaf since age three years. It has been difficult to establish the precise degree of his hearing loss since the child's test responses have always been inconsistent both to testing and to use of hearing aids. Although a confirmed rubella child, his physical defects are limited to his disability in responding to aural stimuli. He has not been acquiring language at an expected rate, and may appear to learn several words one day but on the next will have forgotten them. His intelligence, as measured on non-verbal scales and as estimated in his usage of toys, is above average. He communicates through pantomime, gestures, and facial expressiveness. Currently, the question under examination is whether both the difficulty in obtaining consistent hearing evaluation or remediation and his failure to build verbal word usage may be due to a pathological central language component.

The temperamental characteristics identified in this child's style of functioning are those which should lead to easy and positive use of a program appropriate to his organismic defects. Under circumstances in which he was aware of his competence he exhibited a positive enthusiastic mood of moderate intensity and demonstrated both persistence and adequacy of attention span.

With predominance of positive mood, Nicholas had been from infancy adaptive and approached new situations positively. Intensity was high with positive reactions but negative mood was expressed mildly or moderately. Persistence was high while attention span, distractibility and activity level were all average.

## THE TEACHING SITUATION

With any child, identification of his temperament is just a first step.

The child's individual style of reacting and our knowledge of it must then become one of the factors we attend to in any teaching situation.

With the rubella child, particularly, his physical defects, his intellectual level and his behavioral style must be dynamically integrated in a reflective manner to optimize the possibilities of success of any remedial program.

For instance, if a child has been identified as a very distractible youngster whose attention is constantly being drawn to stimuli that are peripheral to classroom instruction, it is likely he will attend only to part of what he is supposed to do. A demand for such a child to pay attention is pointless. The need is to instruct him in a manner effective for him. This may involve devising special techniques for regaining his attention or dividing the work into smaller units to hold his attention.

When one keeps all these characteristics in mind, one is less prone to become disconcerted by a child's apparent erratic behavior and one will not assume that a child with a hearing loss does not perform because he has not comprehended what he is expected to do. He can be just as distractible or in a negative mood as any hearing child.

## MOTOR ACTIVITY

Similarly, the difference between a high-activity child and a hyperactive child should clearly be kept in mind. Undoubtedly a child with a sensorial loss and the temperamental trait of high activity will be quite a challenge for a teacher. This is a child who moves quickly and frequently and therefore often interferes unintentionally with the activities of other children, and is often restless when having to sit for long periods. In this rapid moving there might be certain goals, certain objectives, but often he does not stay with any task long enough to complete them. If the environment totally opposes the child's activity level, the possibilities are that problems will develop which will further interfere with his capacity to learn. One must also keep in mind that the character

and extent of the management problems that this highly active child will present will in great part depend on his other temperamental attributes. A teacher who will repeatedly make demands on a highly active child for unrealistic restraint of motor activity if not aware of this trait, will tend to interpret the child's inability to comply as deliberate disobedience.

What is needed for such a child are specific outlets for motor activity that neither interrupt his learning time nor interfere with the needs of other children in the classroom. For example, this child can be the one whom she selects to help her erase the blackboard or to water the plants. He should also, like the distractible child, be given only that amount of work to do that he can be expected to accomplish in whatever length of time he is able to sit still.

As was mentioned earlier, several temperamental traits have been found to cluster together. One of these constellations includes initial withdrawal responses to new stimuli followed by slow adaptability and negative mood responses of mild to moderate intensity--"slow to warm up" appears to be an appropriate designation for youngsters showing these traits. This characteristic sequence of response was also found among our rubella children. As we have emphasized before, merely because a child is handicapped one should not attribute his withdrawal behavior to the degree and kind of his physical defects. Thus the rubella child may cling to his mother long after one would have expected him to move easily into his classroom not necessarily because he is insecure or depends on her complete servicing but because this is a youngster who always takes a long time to acustom himself to new situations. Approaching him as if to show him he can survive on his own, is not the

way to handle him at all. This may only result in increasing his withdrawal responses and his negative mood expressions. By contrast, if a teacher allows him to warm up to her in the classroom at his own pace he eventually will accept this as a known situation. Moreover, she must be aware that with each new change that may occur in personnel, scheduling, or teaching material the same initial reaction is likely to occur and she must always guard against assuming that his mastery of one hurdle will allow him to conquer the next with ease. All probably will be just as hard.

## TEMPERAMENT AND BEHAVIOR

With regard to the "difficult child," described in detail earlier, two separate issues must be kept in mind. The first is day-to-day management that takes into account his particular set of temperamental characteristics. The second is the issue of this child's particular vulnerability to the development of behavior disorders.

The problem of handling a difficult child in school has been described earlier in the case of Marie, whose temperamental traits compounded her physical defects, making it impossible for her to learn to the satisfaction of the school. Being a difficult child is not synonymous with having a behavioral disorder. However, difficult children do require unusually consistent and firm handling if they are not to develop an actual behavior disorder. The cluster of temperamental characteristics typical of the difficult child do show a statistical relationship to the development of behavior disorders and thus appears to make these children vulnerable to a whole host of psychiatric problems.

Since a handicapped rubella child is already more likely to develop behavior disorders, how much more at

risk he must be if he also has the signs of the difficult child.

The fact that the child is vulnerable though not irretrievably condemned to develop psychopathology, makes it imperative that handling be

such as to minimize this risk as far as possible.

The overall successful adaptation of any handicapped child will depend to a great degree on the appropriate understanding of and response to his behavioral style.

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## TEMPERAMENT AND THE RUBELLA CHILD

Informal Presentation: Stella Chess

This presentation is somewhat different from the others which have been research-designed from the very beginning, so I will explain the clinical base of both the studies involving children with visual loss, and the temperamental studies which are the point of reference for our paper.

I am a child psychiatrist, and while I have been engaged in behavioral research for many years, they have all derived from a clinical question, and the focus of the behavioral questions that I, with my coinvestigators, have put into research design have always been oriented toward answering a clinical question. Let me start with the children with sensory defects.

### RUBELLA BIRTH DEFECT EVALUATION PROJECT

This study was in fact a prevalence study of the behavioral consequences of congenital rubella. I will make reference to a few tables in our book, *Psychiatric Disorders of Children with Congenital Rubella* by Chess, Korn, and Fernandez; published by Brunner Mayzel in New York. This study arose from the request of our pediatric department at New York University Medical Center to help out with the children who were being studied in the Rubella Birth Defect Evaluation Project, under the direction of Dr. Lewis Cooper. At that time these children, who were born of the 1964 epidemic, were getting close to their second birthday and Dr. Cooper and his staff were discovering what is also the focus of our paper, that their definition of organic consequences was not sufficient to answer the needs of the children and of the

people taking care of them; that there were behaviors showing up that had to be taken into account.

The original request was that I help out clinically. I was at that time designing the liaison service of child psychiatry to work within the Department of Pediatrics. After watching some of the children being examined and going over some of the physical data that had come out of Dr. Cooper's study, it was very evident to me that nobody that I knew of had any idea of the magnitude of the problem. It could not be gotten from Gregg's work in Australia nor even from the Swedish longitudinal study. The first thing that needed to be done was to design a prevalence study. The aim was to study children with congenital rubella, and not children with sensory defects, but obviously the question of sensory defects came up as part of the study. I think it might be of interest to identify the visual defect in the context of the overall findings. Then I will define temperament, and finally discuss the basic point.

### CRITERIA

We were able to bring in or go out to for study, 243 children who were subjects in the Rubella Birth Defect Evaluation Project. These were 243 children for whom congenital rubella was virologically substantiated. The physical status of the children was as follows: Fifty, or 20.6 percent, had no defect identified at that time (everything is always "at that time" because rubella is the kind of disease where you cannot know whether the status will be the same at a later date). One area of defect was identified for 72 of the children

or 29.6 percent. Two areas of defect, 47 children or 19.3 percent. Three areas of defect, 47 children or 19.3 percent, and four areas of defect for 27, or 11.1 percent. This adds up to 99.9 percent.

The areas of defect that we used were visual, hearing, neurological, and cardiac. We did not try to identify others there could have been, such as immunological capacity and so forth. We held to these four areas as being the more pertinent for our purposes.

Another view of the children could be by specific defect only, without regard to whether it was alone or in combination. Visual defects--that is all levels of actual visual defects, but not retinopathy if, although identified by the ophthalmologist, it caused no visual loss. We felt it was better to exclude it, so I do not mean a finding such as speckles, pigmented retinoma in which there is no visual defect at all. Visual defect included 80 children or 32.9 percent. Hearing defect included 177 children who had some degree, or 72.8 percent. Seventy-nine children or 32.5 percent, at that time had had neurological defects identified. Cardiac defect had been identified in 79 children, or 32.5 percent. These data are all from the Rubella Birth Defect Evaluation Project.

Looking at the data on the physical defect combinations, I have rearranged it, for the purpose of our discussion, in terms of focusing on the visual. The Rubella Birth Defect Evaluation Project used a categorization of mild, moderate, or severe. Using their categorization, I sublisted the children with visual defects in terms of visual defect mild, moderate, and severe, but I omitted the question of the degree of hearing loss, or the other severities.

## FINDINGS

No child had mild vision defect alone. In rubella, by the time the visual apparatus is affected, it is unlikely to be alone. It tends to be affected in those children whose mothers had rubella in the earlier periods of the pregnancy, when other structures were forming. There was

no child with only mild visual defects. With double defects in the visual-defect, mild group; one with neurological, none with cardiac, three with hearing. With triple defects: visual plus cardiac and neurological, two; plus hearing and cardiac, none. With quadruple defects: visual, hearing, neurological, and cardiac, two children. I am leaving out the question of retardation. It is charted in the book, but I do not want to complicate matters here.

With visual-defect moderate alone, two children. With double defect: neurological, zero; cardiac, one; hearing, eight. With triple defect: cardiac and neurological, one; hearing and neurological, five; hearing and cardiac, 13. With quadruple defects, that is moderate defect in vision plus hearing, neurological, and cardiac defect, 12.

In the visual-defect severe group there were two children with this as the only finding, at that time. With double defect: neurological, zero; cardiac, one; hearing, three; hearing and neurological, four; hearing and cardiac, four. With quadruple defect in which the visual defect was severe, 18.

## PSYCHIATRIC STUDY

So you can see that the characteristics of this group of children are such that this would be a pretty poor study design if the purpose was to study only visual defect. It came in a very complicated series of packages as far as our children were concerned. This for us was background data. I am putting aside the psychiatric findings, except to say that 37 percent of the children by the best of Dr. Fernandez' ability to test them, were retarded. If we assume that in 243 children you could discount five of these, let us say, it still leaves a good third.

We did a psychiatric, psychological study on the children. We interviewed the parents. Part of the purpose was to get an idea of what their coping devices were with the children, what the impact was on the family with children with this range of difficulties, what facilities there were for the children and how well the parents were using them. Of course, with

the specific children whom we studied, we had our data available for the purpose of making plans.

## TEMPERAMENT STUDY

Because of our interest in temperament and because of our previous experience--Dr. Fernandez was one of the early people in on the temperament studies, too--we were aware in advance of the importance of individual reactive capacities. We had studied these originally normal children and subsequently, before we moved into the rubella study, we had also been involved in a study of mentally retarded children in which temperamental individuality was one of the factors.

The first group of normal children we studied was a middle-class group, and the oldest of these is now 16. The second group, started about five years later, was a group of children of Puerto Rican parentage from stable working-class families. The oldest of these children are now 10. So it was a fair range of children. Let me explain then about temperament, its importance in the normal children, and then in the children who have one or another or several simultaneous handicaps.

The temperament study was also derived from a clinical question. The original impetus came from Dr. Thomas and myself, who besides having four children had discovered in our clinical practices that a good deal of psychodynamic explanation just did not explain things as frequently as it ought to. There were many children among Dr. Thomas' patients who, according to child response to pathological parenting, should not have been disturbed and were. In my child practice, there were many children who according to theoretical formulation should have been disturbed in one manner and were disturbed in another manner; or for whose disturbance I could not find adequate explanation in my investigation of the parents, unless I was ready to say that despite the fact that I could not find it, the theory had to be right, and therefore it was even more subtle and the poor child had a harder time dealing with it. This kind of circular reasoning is not very scientific, and did not satisfy either of us.

It took us 10 years of thinking this over; whether there was a missing dimension, or whether there was a dimension which at least would add something to the story. We came up with individual styles of reactivity. Without going through the early attempts that did not work and how out of each thing that did not work came a clue to something else, we finally changed the title of *Style of Children's Behavior to Temperament*, and we worked out a protocol for getting objective descriptions of children's behavior in response to a described parental act from an early age. We had these descriptions down in protocols which we then found we could not analyze quantitatively until Dr. Birch joined us, and from that time all of us have worked together.

## NINE BEHAVIORAL QUALITIES

We isolated nine qualities of behavior represented in all of the children--there were other qualities that were represented in some and not in others--which we could define, which we could score, and which we ran through the usual scorer, rescorer, and two scorer reliability analyses, and parent interview against a child observation, and so forth.

These temperamental qualities, as I said, came out of descriptions of children. They are obviously not the only possible descriptors of children's style, but they seemed to be important in several ways. They described the child. They were important influences on the parents' handling of the children. They seemed to have some relationship to the ways in which the child responded to increasingly complex demands, and as we later found out, they had a reliable relationship to the probability of adapting well or adapting ill. They are as follows:

1. Activity level, which is purely motor. These qualities come out of every aspect of the child's life, and has to do with how fast and how often there is movement.
2. Rhythmicity of biological regularity, how much there is predictability in rhythmicity or unpredictability and arrhythmicity in time of any function.

3. Approach-withdrawal, which has to do with a positive or negative initial response; the child's approaching positively or withdrawing from either a new or altered stimulus or a change in schedule.
4. Adaptability, the next quality, is separate although often related. After the child's initial response, does he then quickly adapt or does his adaptation to the new or altered situation take a long time.
5. Intensity of reaction is a question of vigor. How much intensity does the child give to the reaction without regard to direction of the reaction? If he is happy, is he very happy, characteristically? If he is disappointed, is he very disappointed? If he is hollering, is he giving it all he has, as opposed to the child who gives mild representations of moods or other children who do not have an all-or-nothing or a characteristic level, but may have selectivity of intensity under varying circumstances.
6. Threshold of responsiveness has to do with the intensity level of the stimulation, not of the response. Any response shows that the stimulus has been perceived, but how much of a stimulus is there? Is it a small noise or a loud noise?
7. The quality of mood; taking 24 hours and totaling up his moods, is the child more often pleased or more often displeased on an average for the day?
8. Distractibility involves the ease with which a child can be diverted from an ongoing activity by extraneous peripheral stimuli.
9. The final category is a double one with which we had much trouble until we united them because the influence of the two is in the same direction; the combination of attention span and persistence. Attention span means continuing with an activity without ceasing, and persistence means characteristically

going back to that from which he was distracted.

We found we could identify these behaviors in our first normal population; "normal" in the sense that the children were identified at birth just because of their belonging to a group which seemed to be rather uniform. We did not want very many variables in their situation, and all had been normal pregnancies and deliveries.

Three did turn out to have organic pathology which one would expect in 136 children. One is a retarded child with amyotonia, and other very soft neurological signs. Another is a child who was premature and had pneumonitis at birth. He was very late in both motor and language milestones, extraordinarily late in verbal behavior, with the first word at age four. He has a superior intelligence and still has some language defect, which is at this point a remnant of dyslexia. There is no severe behavior problem, however, nor indication of any behavior which one would correlate with cerebral dysfunction. The third was a child who did have both neurologic signs of a minor degree and behavioral signs that correlated with them. At one point he was in a children's diagnostic institution where they made the diagnosis of schizophrenia, and in fact it was a schizophrenic adaptation in a child with neurologic dysfunction.

The Puerto Rican children were first seen at baby health stations where they were scheduled for their first six-week examination. There were 95 of these children, basically healthy with several retarded children.

## TEMPERAMENT IN BEHAVIOR DISORDERS

To stress the importance of temperament in behavior disorders, I will make it schematic. We found that children with what we have called the difficult child constellation were at risk for behavior disorder (*Temperament and Behavior Disorders in Children*, Thomas, Chess, and Birch, New York University Press.) In general, there were slightly less

than 10 percent of children in the total group who had this particular constellation which included high irregularity, predominance of withdrawal responses to new stimuli, low adaptability to change, predominance of negative mood, and high intensity of reaction. A child with this combination was at quite a risk of becoming a behavior disorder, and although this combination represented a little less than 10 percent of the total children, it represented slightly more than 50 percent of our behavior disorder group. It did not represent a 100 percent risk, however.

We had one particular child of this temperament who got the prize as the best adapted child in the nursery school at the end of the first year, although early in the fall he was a terrible nuisance. He adapted slowly, but when he had finished adapting, he adapted well. There is no predicting the level of adaptation if the child can get through the hurdles without people tossing him out. These were the normal children, and each temperament has its own kind of risk if the child is handled in a way that is dissonant with his needs. I use this as a quick illustration.

## MENTALLY RETARDED CHILDREN

Our study of the mentally retarded included 52 children and they were recruited not at birth but at the time when their mental ages were between four and six. Their IQ's were between 50 and 75, and they have been followed now for six years. They are adolescents at this point. We have just obtained most of the six-year followups on them. The temperament was determined from an interview scored by the same scorers who had done the longitudinal study, whereas I was responsible for the psychiatric diagnosis which I reviewed without knowing what the temperamental scores were going to be. We found that the risk of behavior disorder in the mentally retarded children in terms of the difficult-child syndrome constellation was even greater than with the normal children. In other words, if you have a special problem, the question of style of reactivity and ease of functioning becomes even more important.

These results were to some extent startling, because this was a very privileged group of retarded children. We had identified them in special classes. A number of them came from the special classes in Westchester. They were middle-class children. We picked them to match our original middle-class population so that we would not get any complications of variables. They were children who had always been at home. They had been identified early in the educational sequence so that they had not had to suffer through years of excessive cognitive demands being made on them, and their teachers were trained teachers. Some of them were from private schools for mentally retarded children. There were other children in private schools whom we did not get because although we knew perfectly well that these schools had retarded children, the schools did not acknowledge them. This is an interesting commentary. They only had emotionally disturbed children, officially. This was at the time when emotional disturbance was considered more reversible and was more dignified, presumably, to parents. There were fewer educational and social options open to the cognitively handicapped, and the negative aspects of temperament assumed even greater importance.

## RUBELLA CHILDREN

In the case of the rubella children the project was a prevalence study, but we were also participating in the clinical service to these children. We were providing the data for the use of the Rubella Birth Defect Evaluation Project and inevitably in some cases it fell to our lot to negotiate with the schools. The children with congenital rubella were between two and one-half and four years and some months of age at the time we examined them. Of course, they stayed with us a while longer.

The defects of these children were defined to the utmost degree possible. The degree of hearing loss was identified, if it was identifiable. Difficult as it is to identify degree of hearing loss in a young child, it seems even harder in the rubella children. In fact questions have been raised whether the rubella hearing

defect is both peripheral and central in some cases. Perhaps this is some explanation for the difficulty in identifying in these children the exact degree of hearing defect and why for some of them the effects of hearing aids are so unpredictable and do not give the correction expected. Visual defect had been identified, and if remediable it was remediated, cataracts were removed, glasses were given. The cardiac defects were, surprisingly to me at that time, the least of everybody's problems. Most of the children were 1A or 2A and a number of them have had some surgery. They were not fatigued. The cardiac difficulty was present but was not a crucial factor in their lives. The neurological problems were, however, and the neurological answer is not completely known because it is hard to get accurate results with early neurological examinations.

## SERVICES

The defects having been defined as well as could be, the children were sorted out to those services that were deemed right in terms of the cataloging of their defects. However, there were always a number of children who could not make it, or perhaps the places could not make it with the children. As we looked over some of these children, again the issue of temperament was a very important factor in a great many cases.

Let me give one example, of a child who has only a hearing defect; this is not a rubella child, but the example is very clear and typical. From whatever testing one could do, she is of normal, probably superior intelligence in terms of level of play, use of puzzles, figure drawing; and also judging from an ability she has learned in dealing with her mother to both try to manipulate people against each other, and to recognize when it is not going to work any more and to give up. She is good at both. The school suggested that she go to a school for emotionally disturbed children because she was so impossible in the classroom. She would not do as the teacher asked. There were times when she would be a nonparticipant, and there were other times when she would rush and grab what another child was doing. In fact, the first

time I saw her she bent most of her efforts to getting herself and her mother away. In the course of this I managed to do an excellent psychiatric mental status.

She was organized. She knew exactly what to do. She took her mother's pocketbook and marched down the hall in a very determined way. As soon as she was out of sight her footsteps became more tentative; you could hear them coming back. She peeked around the corner to see if her mother was running after her in alarm, which she was not doing. She came back, became involved in some activity briefly, and then she tried other gambits. It was an organized, purposeful approach. Her mother had told me ahead of time that whenever she gets into a new situation she wants out, and that this is what she would probably do.

I saw her again about six months later. At this point, I was apparently no longer new to her. She was very happy to involve me in activities and this was the warmed-up child, the adapted child whose behavior was fine except for what the mother reported, that she would not demonstrate to the teachers at school anything that she had learned from her mother at home.

This child was not disorganized. She did not belong in a school for the emotionally disturbed. I do not know whether a school for emotionally disturbed children would know what to do with a child with a visual or a hearing defect. They are not trained to deal with these children's needs. This child's school, which was very busy with more children than it could handle, chose to deal with those youngsters whose temperaments were such as to fit in with their program. If this child left, they would have another one in her place, and in a sense they have the right to do this. I think every school has its right to say how they want to run their school, and that it is only for children who behave in such-and-such a way. I think it would be better to say exactly that, rather than say that the child is emotionally disturbed which means something else.

In the same way our multihandicapped children, including the visually handicapped, did well if they

happened to be of the easy temperament, quick to respond to something new, quick therefore to participate in what was going on, mild in their expression of emotion. Nobody actually minds if a child is exuberant with joy, but intensity of the negative kind disrupts a class. Regularity or irregularity does not play a part in the classroom, but it does in the parent-child relationship. Negative mood is very important. If a child is more often against than for anything it is very disruptive.

## TEMPERAMENT AND SENSORY DEFECT

So out of these data we came to the conclusion that in dealing with a child with sensory handicaps and identifying what his needs are academically, the temperament or behavioral style should be identified along with the sensory defect. In trying to arrange for the proper handling of the child, this should be part of the information given to the place you are sending the child. If you have to hide a difficult temperament in order to have the child

accepted you might as well save yourself the trouble, because he is not going to last. There is no value in this because what is wanted is for them to give the child what he needs.

So it is important to add to the description of children capacities and incapacities this particular stylistic aspect of the child's behavioral capacities. I want to make clear that I am not talking about psychiatric pathology. That is a very different matter. I am talking about the temperamental aspects of the child which are there whether there is pathology or because all pathologies are not identical. Children bring to their healthy behavior and their pathological behavior these same qualities, activity level, intensity, approach-withdrawal, speed of adaptation, persistence and attention span, and distractibility. These are all present in the pathological behaviors. Two brain injured children, who could both be described as having typical behaviors of the brain injured, might be very different management problems in a program designed for children with just these basic problems of cerebral damage.

Discussant: Joan Chase

In discussing the paper by Drs. Chess and Fernandez I will begin by commenting directly on the paper itself, and on the kind of work they are doing. I will then proceed to make some more general remarks on what I see as the present needs of our field.

## EARLY CHILDHOOD

I admire the type of analysis Dr. Chess had presented and has been pursuing over the years in her writings. It provides a necessary and viable theoretical framework within which to view and evaluate infant and early childhood behavior. Mrs. Fraiberg has referred to the scarcity of developmental and language scales. We do not seem to have assessment sophistication for this group that we have for older children. Dr. Chess' particular vision and her perception of temperament has been of tremendous help to many early childhood centers. I think her work, Dr. Escalona's work, and others studying early reactivity levels has been a tremendous contribution to the field. Credit is due Dr. Apgar in this regard, because she demonstrated so many years ago that there are some good predictors immediately after birth; that we do have ways of viewing behavior early which give us some guideposts as to how to proceed.

## NEED FOR INTERVENTION

Concerning the entire concept of high risk for difficult children, those of us who have been working with handicapped children for many years have been talking about the need for early intervention. Over the years we have developed a body of knowledge by which we have been able to identify high risk or problem children at an early age. Certainly, in the field of blindness, we have seen the waves of

children coming to us, the rubella wave and the RLF wave, and ophthalmia neonatorum before that. Each time there was a very real concern expressed; and there now exists a body of literature which might have been of service.

Many centers have, of course, instituted early childhood development projects such as Dr. Fraiberg's. The School for the Blind in Batavia, New York is one example where every summer over the course of 10 years parent-child institutes are held. Such specific procedures are needed to alleviate the effects of some of the early damage we have seen over the years. I think Dr. Friedlander is right in that we cannot rely on a natural course of events to overcome some of these developmental difficulties and delay that we see. In order to do this we need theoretical models and very concrete ways of approaching the problems. By now we are seeing this concept of high risk and early intervention becoming more accepted through the work of professional researchers such as Dr. Chess.

## PARENTAL NEEDS

The third area, which is so important, came through to some extent in the paper, that is, the recognition of parental needs. In using this framework of temperament, of high risk, and of neurological damage, we can encourage guidance of parents along what I would call other than guilt-producing lines. We can at this point say to parents that there are some apparent stylistic and/or physiological differences in children. Parents of handicapped children have the same kind of defense patterns that we all display, although they become more extreme and acute because of the presence of this type of problem. One of the things that becomes most acute is the

issue of the *good-mother/bad-mother* self-perception. In all the parents' groups that I have conducted such feelings have to be recognized first. We are emerging from an age of stress upon parent behavior as being all-controlling and all-predicting, into an age where we can look at the interactional effect between infant and parent and help parents to feel better equipped. There is an analogy in the way the parent of the young handicapped child probably has felt over the years to the feelings of parents of today's very reactive adolescents. A friend told me recently that she was not equipped to cope with her three adolescents. Parents of handicapped children have felt this and have been ashamed of their inability to cope. We, for our part, have failed to provide appropriate assistance. They have been afraid to admit many of these feelings, and we have inhibited a kind of communication that would have been extremely helpful for both the parent and the child.

## RUBELLA

The fourth point is in response to the issue of rubella itself as a syndrome and rubella as it exists today. Rubella more probably than any other disorder that we have seen (although RLF had some similar characteristics) exemplifies our problem of gradients. We are seeing many more genetic disorders, many more multi-handicaps, and similar complex disorders that appear in gradient form. With such gradient disorders it is almost impossible to generalize, not only from one group to another, but from one child to another. We have difficulties in looking at this group as a homogeneous population. Although rubella is today probably much more preventable than ever and hopefully totally preventable within the next 10 years, we can deal with the rubella population with a sophistication that we failed to offer in many ways with the RLF population. We can look at this population to see how one can deal with gradient differences of behavior and gradient differences of handicaps.

Before the study by Dr. Chess, our knowledge of this particular group was anecdotal. When I learned that I was going to react to a paper

on rubella, I looked up my own former experience. In my work at the New Jersey Commission for the Blind, I taught seven postrubella children. Two of them are presently working. Both, I might add, are relatively socially unacceptable. They are marginal people. One is working in a sheltered shop situation. The other is running a candy stand, which is a typical position for a blind person not well rehabilitated. Both had cataract surgery, with lenses prescribed. These are the only two of the seven who are, to any degree, independent at this point. I am familiar with Dr. Cooper's statistics on the effects of rubella in today's younger group in New York. Either the recent epidemic was less severe or action was taken in a more appropriate way to assist these children. Formerly the tendency was to leave the cataracts until they matured or until the child came of school age, so usually they did not receive their surgery until they were six or seven years old.

Time contrasts are interesting. The older rubella group is now about 18 years old, and there was approximately a 12-year interval between epidemics. With regard to the RLF we have something like a 20-year retrospective interval. In a study of RLF subjects in New Jersey approximately one-half of the group of 263 are functioning at least two grades below age expectancy or in sheltered situations only. I found that 49 percent either needed total supervision or were severely delayed in their social functioning. I believe that many of the older youngsters, had they received early assistance and the type of analysis of functions and skills that this rubella group has been given, might have been able to achieve a higher functional level.

However, there are real differences between these two groups. From my own observations, rubella children tend to be more phobic about touch and tactile stimulation than were RLF's, and the extremes in terms of light and of fascination with light which you often see in the rubella group, was much rarer in the retrolental group.

Parental issues compound the differences between groups. Parents

today are often faced with a choice between abortion and childbearing if the mother has been infected by rubella. When such a child is delivered at term, and found to be handicapped, the parents often suffer confused feelings of responsibility, guilt, and related conflicts. In contrast, the parents of RLF children, when confronted with extreme prematurity, were often relieved at the outcome when the infant survived. Such family reaction variables present considerable differences in approach to early childrearing.

## INNOVATIONS NEEDED FOR SPECIAL POPULATIONS

The fifth issue is the whole area of developing repertoires for working with severely handicapped children. The findings of specific deafness in rubella children is tremendously important. We find children who, on hearing tests, very often turn out to be less hearing impaired than they appeared to be and if we have this information early enough, we can make specific recommendations for learning along lines more appropriate to aphasia than to deafness.

Denhoff and Robinault presented a continuum of disorders in a book, *Cerebral Palsy and Related Disorders*, published in the early 1960's. They provide a framework for viewing neurological disorders as a continuous process of impairment. With the rubella group such overlap is most striking. Since most of the children we now see are multihandicapped, it is necessary that we look more closely at early childhood, and write specific developmental prescriptions that address themselves to particular problems. We must view the individual child rather than think in terms of a blind group, a deaf group, or a cerebral palsy group. Such sensitivity to individuals is particularly necessary when we approach patterns of genetic disorders, such as the retinoblastoma population now being studied.

## RESIDUAL SIGHT

The sixth point is the use of residual sight in rubella and other conditions. I am somewhat disappointed that there has been no discussion during this conference regarding the

use of visual training in the early lives of these children. One of the infants in the film showed was definitely using a visual cue in reaching out. If you have seen the difference between the totally blind and those with even the smallest amount of vision, you know that this vision gives tremendous input. In the case of the rubella group the lowest acuity was light perception. I have not known any totally blind post-rubella children. If you begin to work with the youngster at two, you really have no sense of the meaning of light perception for that child. This topic has not been discussed at all, and perhaps the development of training programs appropriate for that age is a direction for the Research Department of AFB to consider. We now have some good data which demonstrates the positive outcomes of visual training for older children such as the work by Dr. Eleanor Faye in New York, and Dr. Natalie Barraga in Texas. There are ophthalmological studies in the journals which also report that you can increase visual usage and efficiency in children when you offer graded visual experiences in a structured setting. Once again, the value of consciously planned instruction rather than "letting nature take its course" is demonstrated.

In addition to the sensory processes, tactile, auditory, and haptic that were discussed here, we need to address ourselves to a program for the development of visual effectiveness in children with very low vision. Since it has been demonstrated with older children, I assume that we could see some very real changes in use of vision among younger children if we started at an early age. Here again, our RLF experience is somewhat relevant in that we did not intervene soon enough to capitalize on the residual sight some of the children had. We need to work toward the development of sequences of activity for very young children in many directions, but specifically in terms of visual training.

## EDUCATIONAL FUNCTION

The seventh point is the important educational function which Dr. Chess has performed for all professions. Unfortunately, many professionals remain unaware of the importance of

early intervention. Many of us have heard stories of encounters with physicians, and others in the health professions, in which parents of infants and very young children were offered false reassurance or misdiagnoses. We are beyond the stage in our knowledge where any concerned parent should be forced to wait for school age or advised that a child will grow out of developmental difficulties naturally. An extremely valuable contribution of the study is the demonstration of the need to be sensitive to and aware of the predictive effect of neonatal problems. The example of cerebral palsy is pertinent. Delay in offering the necessary therapies often results in greater physical disability.

The urgency of this educational function cannot be overstated. We must train a new generation of health professionals willing to investigate every suspected problem no matter how young the child.

## PREVENTION

Having responded to Dr. Chess' paper, I have some general comments regarding early childhood development. What has been discussed at this conference is secondary prevention. We have been talking about the prevention of overlay problems, of complications, of developmental delay resulting from specific impairment. Yet there is a great deal more that can be done in terms of primary prevention. Rubella is the perfect example. Our present ability to prevent the disorder in the first place is being, to some extent, impeded by the lack of funds for inoculation programs around the country. We have to make a priority commitment to preventive programs first.

It is difficult to get funds for prevention programs. Funding agencies are less likely to support such programs unless of dramatic impact such as the Salk vaccine. Not many people in the country are currently writing letters to legislators, etc., expressing gratitude that their child has been spared from polio. There is a problem in keeping prevention programs moving because once a disorder is in fact prevented, it does not attract much attention.

There is a story which illustrates this well. A meeting was being held, and a man rushed in very late and very breathless. He excused himself for being late, saying he had just saved a woman from rape. Pressed for details of what had happened he explained, "I changed my mind." If you look at the story in terms of the whole problem of prevention you realize the woman may or may not have been aware of that preventive decision. Such is the problem of selling preventive programs before the need for them is evident.

## NEW PROFESSIONAL ROLES

The second action that I would like to suggest is the development of new professional roles. We have known for many years that if we began to work with these youngsters early, a number of positive effects would accrue that would have implications for their ability to function for the duration of their lives. Suggestions have been made for the creation of new professional roles, such as home visitors, regional child care workers and specialists in infant development. Unfortunately, we tend to develop diagnostic centers, but few true service centers.

## TECHNOLOGY

To my knowledge, the possibilities of using technology meaningfully to foster development in infants and young children have not been explored. In England, there have been a few attempts to create "responsive environments" which would elicit behaviors (specifically, types of movement) from impaired young children, as in the cases of post-thalidomide patients.

Rarely do technical advances sift down to serve human needs on an individual basis. We might foresee means of infant stimulation using sound, light, motion, and other adaptive mechanisms right in the home. Whatever our view of behavior modification techniques, we must recognize that many of Skinner's proposals for early development can have specific beneficial effects for the handicapped.

Technology in concert with informed parent handling may provide a means of reaching populations not now served. It also offers means through which human interaction can be improved when properly utilized.

### TRAINING FOR PARENTHOOD

We need to train young people in an understanding of child development as preparation for parenthood. In such training, issues surrounding handicapping conditions of childhood could be included. It would be profitable even if it meant simply that there would be more understanding neighbors to a mother of a handicapped child.

### EMPOWERMENT OF PARENTS

We need to restore to parents the sense that they do indeed make decisions for their children, and in many cases, very positive ones. Some interpretations of child psychology and child development theory

we give parents the sense that anything they do has a negative effect. Parents need to feel a sense of power, ability, and competence in child rearing. That might indeed mean training of the parents as a part of our professional team within the framework of specific programs for children.

### COMMUNITY RESPONSIBILITY

Parents of a handicapped child deserve the support of a community network of services. Such children must be seen as the responsibility of the entire community. We tend to exclude the severely-deviant child, such as the psychiatric and profoundly retarded populations, from care and services. Hopefully, events such as the Willowbrook expose in New York will focus the needed attention on such problems. Local community groups must organize to serve those families in greatest need of comprehensive services.

## General Discussion

Referring to Dr. Chase's remarks on the importance of prevention programs, Dr. Parmelee commented that the rubella vaccine had not really fulfilled expectations in terms of immunity. He conceded that this did not preclude the development of new vaccines, which might work better. But at the moment it was somewhat deceptive.

### SLOW VIRUS IN RUBELLA

Dr. Parmelee also pointed to a medical concept known as the slow virus, which is difficult to assess. Such virus lives for years, as long as 20 or 30 years, in the brain or in some tissue. The rubella child does not develop adequate immunity to the rubella virus. Although one may not be able to culture the rubella virus after about 18 months of age from the mouth or urine, this does not mean that it is not still alive in the brain. There is a waxing and waning of the rubella child's abilities which we are really at a loss to explain. A rubella child may be assessed at one level one year, and two years later the assessment will be entirely invalid. Perhaps changes have been taking place in the brain due to the persisting viral infection. In the case of hearing, for instance, some may hear and then suddenly become totally deaf due to activation of the virus. Miss Moor commented that this may explain what had been observed at one time with some rubella children on the now discontinued AFB register: there was a waning of abilities past the age of 8 to 12 years.

### EARLY INTERVENTION

Two of the participants commented on additional aspects of the problems of early intervention discussed by Dr. Chase. Dr. Elonen made a plea for

early intervention to enhance the use of hearing, analogous to that for the development of residual vision. She pointed out that the aids that deafness requires can be difficult to sell to some parents, and to some agencies. Mrs. Fraiberg emphasized the lack of professionally trained personnel as one of the major difficulties in establishing early intervention programs. The specialist in early childhood or infancy with clinical training and who, optimally, also has research training, is a rarity. There are apparently no provisions in any of the governmental agencies for the training of the infant mental health specialist, or the specialist in infant intervention. This should be a matter of high priority in dealing with those who empower such programs.

### TEMPERAMENTAL SCALES

To return to the central question of temperament, Dr. Prescott wanted to know whether the temperamental scales had been quantified on a sufficiently large sample of children and subjected to factor analysis. Whenever clinical judgments of behavior are made, the question is always raised whether in fact these clinical judgments reflect independence in terms of the behaviors that have been categorized. In the present case, was a factor analysis performed to determine what portions of the variance were either in common or independent?

#### Development

In replying, Dr. Chess described the development of the scales from their inception. She and Dr. Thomas had discussed their ideas on the subject for about 10 years, until they had a clear idea of "style." Then taking 15 children ranging in ages

from 5 to 15 years, whom they had known well, they did retrospective histories on them, trying to find what behaviors had persisted throughout life. After trying various concepts that did not work, including conditioning, they came to the conclusion that if they asked questions and restricted themselves to taking down verbal replies, they might have data that could be analyzed. At this point Dr. Birch, who had not been involved up to that time, provided a fresh look. He developed inductively from the data a group of qualities about which they then proceeded to argue. This was a mammoth argument in which they argued definitions, meanings, and contaminations, until they felt they had discreet definitions. It was at this point that attention span and persistence were combined because they could not be reliably distinguished. Where this kind of difficulty arose, categories were re-examined and either, as in this case, were collapsed or different ones worked out.

The scale was originally a five-point scale. In defining the quality of what was being scored, it was found, in some cases, that the scoring was high, medium, and low, in others high, variable, and low, depending on what the definition of the quality was. It was also found that the central point was reliably scored but neither the one and two nor the four and five points on the scale could be reliably differentiated from each other. It was then made into a three-point scale for all temperamental dimensions. The details of this have been reported in a monograph called *Behavioral Individuality in Early Childhood* by A. Thomas, S. Chess, H. Birch, M. Hertzog and S. Korn, published by the New York University Press. This report took the group of children studied up to their second birthday; and it is largely a report of study design and study results.

### Factor Analysis

On the basis of inspection and their experience, the research team put together the temperaments they thought would cluster and then factor analyzed them. The factor analysis came out almost exactly as expected. The factor analysis that the computer

produced has been kept. Activity level stands by itself, as it did not factor as reliably as the others.

### Physical Contact

Dr. Prescott then asked whether, in her studies, Dr. Chess had been able to relate the degree of physical touching and handling, in either normal or aberrant children, to temperament. She replied that this was not one of the things their studies had been designed to observe. In taking a detailed history only three months after the previous one, if it includes behavior of the child with regard to eating, sleeping, dressing, bathing, etc.; a lot of parental style is recorded. In each case one has to have a description of what the parent did before one can make any use of what the child did. But unless handling had been built in specifically to make sure that it was recorded, one would not be likely to get anything but an impressionistic answer to this question. The scoring on temperament is an item scoring. The histories were worked out so that there are discrete items within them. One descriptive item might in fact have several qualities which can be scored from the same sentence, but they are discrete items.

### Stability of Temperamental Characteristics

Dr. Berkson asked Dr. Chess to comment on the stability of temperamental characteristics. From her present remarks he gathered that she felt these were present at birth and remained over time. His impression from some previous work, however, was that she had a reactive concept of temperament; that it was modifiable and that therefore a child's temperament might change with age, depending on the social circumstances.

Dr. Chess responded by discussing some of the follow-up data now available. The children's protocols have been brought up to five years of age and were about to be brought up to date again. Up to two years of age the stability of temperament was remarkable. Between two and five there was some modification. As they became a little older, that modification was found to be partly spurious.

Take for example the child who responds negatively, who withdraws and adapts slowly. Between the ages of two and five, this quality seemed to become less prominent in a number of these children; but as they got to be six and seven, suddenly it became more prominent again. The answer was that by the time a child was two he had been out playing with groups of children, or at least by three or four he had experiences with nursery schools, and he had been through one set of major changes. There were not so many new, or completely new, things. When you get to be six or seven, more new things appear. Children invite you to go to play and your mother does not necessarily come along, and there are various other things that occur. Suddenly the children who were withdrawing and slow to warm up have their tantrums in their first dancing class or swimming lesson or whatever; and the children who were quick to adapt also behave in their characteristic manner. So some of the modifications were somewhat on the spurious side and it had to do not with the children changing so that they were no longer slow to adapt, but with the fact that they did not have as many new things to which to react. Nevertheless, Dr. Chess still felt that there has to be some modification and one of the questions that is being considered is whether possibly the children divide into groups by stability of temperament. Perhaps some having less stability of temperament than others is also a factor of some significance.

#### Behavior Problems

Dr. Chess had been following the children who have had behavior problems, including the children in the Puerto Rican sample. In fact she was at present involved in reviewing the clinical cases and seeing the children who are at age 10 now. It has been amazing how many of the early temperamental qualities still play a part in the adolescent problems of these children from the original sample.

Some of the problems, of course, are no longer purely reactive, they have ideational content and so forth. The child who is highly distractable will now rationalize it, he is the one with the high D syndrome: "I got a D, but it was a high D, and you

should have seen what marks all the other kids got." It was mean; it was an unfair test; he did not tell us he was going to ask that question." This child has remained the same kind of child. When he was in the first grade, he did not pay attention and he tore up his work. He tore out five pages of his work book and assumed that the teacher was not going to notice it, and now he gives the ideological rationalization.

#### Persistence

One almost gets a *deja vu* experience in looking at some of these children. The complications are there, but the persistent child is still persistent. He was so persistent when he was having a vendetta with his teacher that he was almost expelled from school. This is *deja vu* because this was the child who got tossed out of first grade for the very same thing. He was building with his blocks when it was time to go outside and the teacher said, "You will have to put them away." He ignored her, so she began to put them away, at which point he flung a block at her. As this was not the first time he had done it, they said they could not keep him in the school. He was then put in a school where the teacher would allow him to go on with what he was doing and he did arithmetic all morning. The teacher did not take the children out or make them take a break, so at the time of the follow-up interview, he was the best child in the school. One day she would start with arithmetic, and the next day she would start with reading. He was no trouble to her whatsoever. He gave his persistence to the mastering of the material and was suddenly the best child in the school. Three grades later there was another episode, when the thing about which he was being persistent was a thing the teacher thought a child should not be persistent about, so they clashed, and there was another of the explosions typical of this boy.

Some of the continuity has been very fascinating, but one suspects that these dramatic cases may stand out, while the ones where changes have taken place will not. The question will have to be reviewed in an organized fashion to obtain an objective view. The issue is not clear because the relevant material has not yet been analyzed. The younger children must catch up to whatever the follow-up age is, before all the data can be analyzed.



RESEARCH CONFERENCE ON THE EFFECTS OF BLINDNESS  
AND OTHER IMPAIRMENTS ON EARLY DEVELOPMENT

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